Eng.

The Engineer

VOL. 196—JULY TO DECEMBER, 1953

LONDON:
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The Engineer

JULY 3, 1953 | 28, ESSEX ST., STRAND, LONDON, W.C.2 | TWO SHILLINGS

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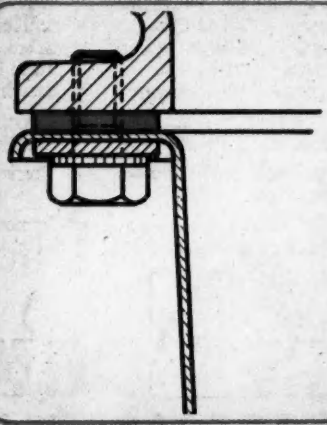

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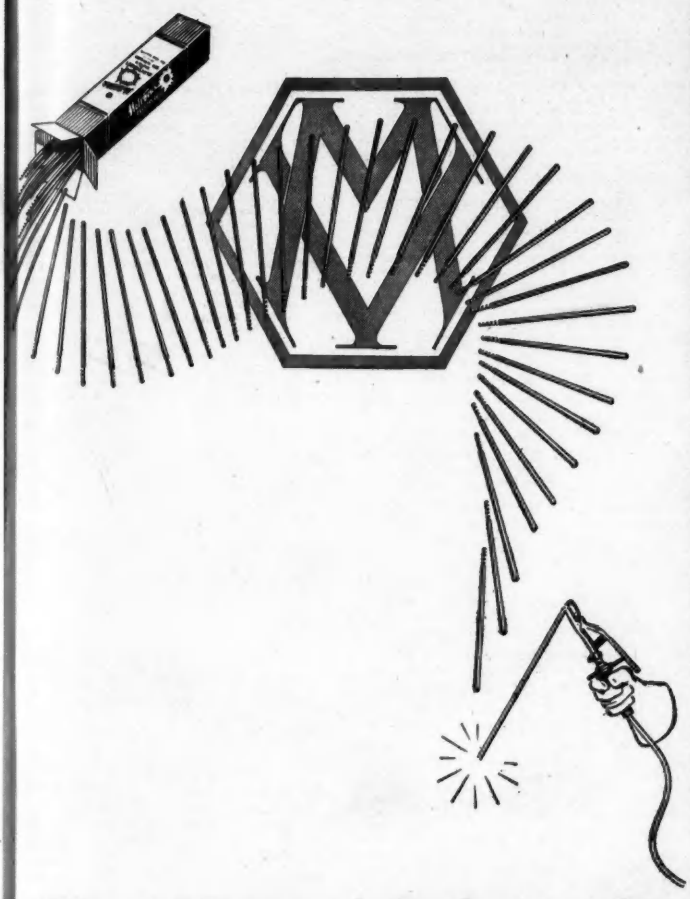

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THE ENGINEER

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NOTICE TO READERS
All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

THE UNIVERSITY OF LIVERPOOL

DEPARTMENT OF MECHANICAL ENGINEERING

LECTURER

Applications are invited for the post of LECTURER in the Department of Mechanical Engineering. The initial salary will be within the range £550–£800 per annum, according to qualifications and experience.

Applications, stating age, academic qualifications and experience, together with the names of three referees, should be received not later than 18th July, 1953, by the undersigned, from whom further particulars of the conditions of appointment may be obtained.

STANLEY DUMBELL,
Registrar.

June, 1953. E9187

SURREY EDUCATION COMMITTEE

KINGSTON-ON-THAMES TECHNICAL COLLEGE,

KINGSTON HALL ROAD, KINGSTON-ON-THAMES

Applications are invited for the undermentioned posts :—

(a) MAINTENANCE ENGINEER. Duties include general maintenance work throughout the College building, including laboratories and workshops of the Science and Engineering Departments, as required. Experience in engineering industry essential and general knowledge of mechanical, heating and electrical installations desirable. Salary scale £420 by £20 to £440 by £25 to £465 by £15 to £495 plus London allowance.

(b) LABORATORY TECHNICIAN, Engineering Department, required as soon as possible.

Duties include construction, maintenance and repair of electronic and electrical apparatus.

Candidates must have experience in electrical work and have reached the standard of the Ordinary National Certificate in Electrical Engineering. Preference will be given to holders of a Higher National Certificate or its equivalent. Salary scale £375 by £15 to £420 by £20 to £440, plus London allowance.

Conditions of service, as for N.J.C. Award for Technical Officers, including superannuation.

Applications, stating age, experience and qualifications, should be addressed to the Principal as soon as possible. E9257

BEDFORDSHIRE EDUCATION COMMITTEE

LUTON COMMITTEE FOR EDUCATION

LUTON AND SOUTH BEDFORDSHIRE COLLEGE OF FURTHER EDUCATION

Principal : W. F. STEPHENSON, B.Sc., F.R.I.C.

GRADE A ASSISTANT IN THE ENGINEERING DEPARTMENT

Applications are invited for the post of Grade A ASSISTANT in the Engineering Department, to teach workshop practice and related subjects to Final C.G.L.I. standard. Applicants should have Final C.G.L.I. Certificate in Machine Shop Engineering or equivalent qualification in production engineering.

Send S.A.E. (foolscap) for application form, which should be returned within two weeks of the appearance of this advertisement to J. A. Corbett, Borough Education Officer, 63–69, Guildford Street, Luton. E9239

COUNTY BOROUGH OF IPSWICH EDUCATION COMMITTEE

SCHOOL OF TECHNOLOGY

Principal : LEONARD R. CHANDLER, B.Sc.Hons. (Eng.), A.C.G.I., M.I.Mech.E., M.I.Prod.E.

ASSISTANT, GRADE B

Applications are invited for the following full-time post :—

ASSISTANT, Grade B, to teach two or more of the following production engineering subjects :—Work measurement, production planning, metrology, jig and tool design, and machine tools, to Higher National Certificate standard.

Salary will be in accordance with the Burnham Technical Scale, 1951, with the appropriate additions for qualifications, training and industrial experience.

Forms of application and further particulars may be obtained from the Principal, The School of Technology, Tower Ramparts, Ipswich, to whom completed forms should be returned immediately.

J. T. HILL,
Chief Education Officer.

17, Tower Street,
Ipswich. E9280

BRITISH RAILWAYS

(SCOTTISH REGION)

ENGINEERING ASSISTANTS

Applications are invited for ENGINEERING ASSISTANTS for the Civil Engineer's Department, Glasgow, with general engineering experience relating to provisional orders, land and wayleave matters, also with general survey and drawing experience. Salary according to age and qualifications.—Apply to Civil Engineer, St. Enoch Station, Glasgow, C.1. E9252

PETERBOROUGH JOINT EDUCATION BOARD

PETERBOROUGH TECHNICAL COLLEGE

ASSISTANTS (GRADE A)

Applications are invited for posts as ASSISTANTS (Grade A) to teach the following subjects :—

Carpentry or brickwork to the standard of the City and Guilds of London Institute Final Examination.

Some teaching experience is desirable. Salary will be in accordance with the conditions of the Burnham Technical Report.

Suitably qualified applicants may obtain further information and forms of application from the undersigned on receipt of a stamped, addressed foolscap envelope. Application should be made within fourteen days of the appearance of this advertisement.

LESLIE TAIT,
Chief Education Officer.

Education Offices,
Town Hall,
Peterborough. E9256

HER MAJESTY'S COLONIAL SERVICE

PUBLIC WORKS DEPARTMENT

CIVIL ENGINEERS

Applications are invited for the following posts :—

Vacancies exist for CIVIL ENGINEERS in various branches of the Public Works Department in Nigeria for employment on civil engineering and irrigation projects, rural and urban water supplies, road development, &c. Appointment is on probation for permanent and pensionable employment, with gross emoluments in the range £830 to £1560 per annum (including basic salary and expatriation pay), or if on contract terms, in the range £895 to £1719 per annum. Officers appointed on contract receive, on satisfactory completion of contract, a gratuity of £25 for each completed period of three months' service, or at the rate of £37 10s. where salary is £1000 per annum or over. Point of entry into basic salary scale determined by age, experience and war service. Candidates, preferably not over 35 years of age, should hold a recognised University Degree or Diploma in Civil Engineering carrying exemption from Parts I and II of the A.M.I.C.E. examinations plus at least two years' approved practical experience or be A.M.I.C.E.

Full details on application.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number CDE 112/14/03. E9253

BRITISH EUROPEAN AIRWAYS

ORGANISATION & METHODS BRANCH

British European Airways invite applications for TWO POSTS in their recently formed Organisation and Methods Branch. Post (A) involves investigation of office methods, accounting and other paper work procedures and requires knowledge of office machines and equipment, including punched card equipment. Post (B) involves investigations of an operational research nature and requires a knowledge of work study, layout planning techniques and mechanical handling equipment. Applicants should have a good University Degree, preferably in Engineering, Science or Mathematics, or a high professional qualification in engineering or accountancy, at least five years' experience in a position of responsibility, preferably in industry, and a minimum of two years' specialised experience relating to the work of one or other of the posts. Salary within the scale £875–£1175 per annum. Consideration will also be given to applicants with the right basic qualifications but lacking specialised experience, in which case salary would depend on basic qualifications. Successful applicants will be required to pass a medical examination and participate in the pension scheme.—Applications, giving full details of age, qualifications, experience and stating the post applied for and when available, to the Chief Personnel Officer, B.E.A., Keyline House, Ruislip, Middlesex. Closing date 15th July, 1953. E9243

HER MAJESTY'S COLONIAL SERVICE

BRITISH HONDURAS

HYDRAULIC ENGINEER

Applications are invited for the following post :—

HYDRAULIC ENGINEER, British Honduras.

Appointment is on agreement for three years at a salary of £1500 per annum. Transport allowance is also paid. Duties would include the investigation and development of small irrigation projects, and potable water supplies (boreholes and wells), and the collection of hydrological data generally. Candidates must possess a University Degree or Diploma in Civil Engineering carrying exemption from Sections I and II of the A.M.I.C.E. Examination, or be Corporate Members of the Institution of Civil Engineers, and must have considerable experience in works of this nature. Quarters will be provided in Belize at a rental of 7½ per cent. salary. Medical treatment is free.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number CDE 112/31/02. E9281

NEW ZEALAND MINISTRY OF WORKS

DRAUGHTSMEN AND ENGINEERS

BUILDING SERVICES DRAUGHTSMEN (Ref. A/B 3/74/85) : Salary up to £860 as merited. Locations : Head Office, Wellington, Hamilton, Wanganui and Dunedin.

Applicants must have had draughting and design experience in heating and ventilating or general building services engineering (mechanical, electrical and drainage) for hospitals, schools, offices and public buildings ; to include boiler and engine plant, heating systems, steam reticulation, electrical distribution, ventilation and air conditioning, lifts and elevators and general building drainage.

Applicants may later be required to submit at interview recent examples of their drawings and calculations.

CIVIL AND STRUCTURAL DRAUGHTSMEN (Ref. A/B 3/74/87) : Salary up to £980 as merited.

Civil Engineering and Structural Draughtsmen are required with experience in the design of general civil engineering works and/or reinforced concrete bridges and other structures. Draughtsmen with experience in the design of steel structures are also wanted but they must be prepared to design in reinforced concrete. The primary requirement is for skilled and speedy draughtsmen.

Applicants should hold Higher National Certificate or be Associate Member of the Institution of Structural Engineers and they may be required later to submit at interview recent examples of their drawings and calculations.

Although preference will be given to men from 25–30 years of age at salaries of £570–£740, there are also vacancies with salaries up to £980, depending upon experience.

MECHANICAL ENGINEERS (Ref. A/B 3/74/86) : Salary up to £800 (in first instance), according to age and experience. Location (in first place) to Mangakino, where married accommodation will be available. Appointees will be subject to transfer at some later date.

Applicants should hold a University Degree in Engineering and/or be Corporate Members of the Institution of Mechanical Engineers.

Applicants should have knowledge of civil engineering construction plant and equipment and be capable of directing staff engaged in erection, operation, maintenance and repair of such equipment. Applicants must be capable of undertaking technical investigations and preparing reports.

Some knowledge of building services, covering heating, ventilation, steam, hot water and electricity services would be an advantage although not necessary for the present positions to be filled.

BUILDING SERVICES ENGINEER (Ref. A/B 3/74/85) : Salary up to £1180—according to experience. Location : Head Office, Wellington.

Applicants should hold a University Degree in Engineering and/or be a Corporate Member of the Institution of Mechanical Engineers. Corporate Membership of the Institution of Electrical Engineers or Associate Member of the Institution of Heating and Ventilating Engineers would be considered as desirable additional qualifications.

Candidates should have served a recognised training period within engineering industry and should have had extensive experience in design, installation and supervision of boiler and engine plant, hot water and other heating systems, steam reticulation and utilisation, ventilation, air conditioning and refrigeration ; lifts and elevator and general engineering services.

Applicants with maximum experience will be considered for the position of Assistant Chief Building Services Engineer at or about the maximum salary advertised and will be called upon for inspections and reports on installations in hospitals, public buildings and defence services establishments. Age of applicants should preferably be between 35 and 45 years.

Further particulars and application forms can be obtained from The Office of the High Commissioner for New Zealand, 415, Strand, London, W.C.2, quoting the appropriate reference number and the name of this paper. Completed application forms must be lodged at the above office not later than Friday, 7th August, 1953. E9304

ESSEX RIVER BOARD

APPOINTMENT OF NORTHERN DIVISIONAL ENGINEER

Applications are invited from chartered civil engineers for the post of NORTHERN DIVISIONAL ENGINEER (Colchester Office), Grade A.P.T. VIII (£760–£835).

Applicants should have had experience of River Board works and organisation, preferably including coastal defence work.

The appointment will be subject to the provisions of the Local Government Superannuation Act, 1937.

Application forms may be obtained from and should be completed and returned to the undersigned not later than 15th July, 1953.

W. J. S. BEW,
Clerk of the Board.

Essex Rivers House,
Springfield Road,
Chelmsford, Essex,
26th June, 1953. E9287

MINISTRY OF SUPPLY

ENGINEER

Ministry of Supply require ENGINEER at Christchurch, Hants, to design, develop mech. equipment, including earth-moving and road-making plant for Services. Qualifications : British of British parents. Recognised eng. apprenticeship and A.M.I.C.E. or Mech.E. or E.E. or exempting qualns. Suitable design experience. Salary : Within £928–£1218 p.a. Not established but opportunities to compete for establishment may arise. Application forms from M.L. and N.S. Technical and Scientific Register, 26, King Street, London, S.W.1, quoting Ref. C345/53A. Closing date July 25th 1953. E9262

CENTRAL ELECTRICITY BOARD

FEDERATION OF MALAYA

ELECTRICAL ENGINEER (DISTRIBUTION)

ASSISTANT POWER STATION SUPERINTENDENT

OPERATION AND EFFICIENCY ENGINEER

ELECTRICAL ENGINEER (DISTRIBUTION) (M2C/29433/EH), ASSISTANT POWER STATION SUPERINTENDENT (M2C/28769/EH), OPERATION AND EFFICIENCY ENGINEER (M2C/28770/EH) required by the Central Electricity Board, Federation of Malaya. Option of appointment either (a) on agreement for three years with prospect of permanency, or (b) on contract for three years with gratuity of £200 or £280 for each year's service according to salary. Allowances additional to those mentioned below and ranging between £21 and £630 a year, payable to married men according to salary and dependants. Free passages. Liberal leave on full salary. Opportunity of termination appointment at the end of one year if so desired.

Electrical Engineer (Distribution) : Salary (&c.) equivalent to £1218, rising to £2100 a year. Candidates must have had sound training in both electrical and mechanical engineering with experience in the operation of medium electricity supply undertakings and possess a competent knowledge of the maintenance of high and low tension overhead and underground A.C. distribution systems and substation plant. They should preferably be Corporate Members or Graduates of the Institution of Electrical Engineers or possess Degrees or other qualifications carrying exemption from the Institution's Graduate examination. Those not so qualified would be eligible for salary in scale £1197, rising to £1862 a year.

Assistant Power Station Superintendent : Salary (&c.) equivalent to £1904, rising to £2100 a year. Candidates must have wide experience of station maintenance and operation and preferably have held a similar position in a steam power station of not less than 80MW. capacity or as a charge engineer for at least 5 years on a station of not less than 120MW. capacity.

Operation and Efficiency Engineer : Salary (&c.) equivalent to £1687, rising to £2100 a year. Candidates must have had good power station experience including some years as a charge engineer in a modern steam station, and have a knowledge of the principles of combustion, thermal cycles and heat balances, system control and the economics of operation. Candidates should preferably be Corporate Members or Graduates of the Institution of Electrical or Mechanical Engineers or hold an equivalent qualification. Those not so qualified would be eligible for salary in scale £1673, rising to £1862 a year.

Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote reference number against appointment for which application is made. E9303

HER MAJESTY'S COLONIAL SERVICE

ROADS BRANCH, PUBLIC WORKS DEPARTMENT, KENYA

ENGINEERS

Applications are invited for the following posts :—

ENGINEERS, Roads Branch, Public Works Department, Kenya.

Appointment is on contract ; salary in the scale £830–£1410 p.a. plus cost-of-living allowance at the rate of 30 per cent of basic salary (maximum £1 p.a.). Substantial gratuity payable on satisfactory completion of contract.

Candidates must hold a recognised University Degree or Diploma in Civil Engineering, carrying exemption from Sections I and II of the Institution of Civil Engineers examinations, plus at least two years' approved practical experience, or be A.M.I.C.E.

Duties would include investigation, design, construction and maintenance of roads, bridges and aerodromes.

Full details on application.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number CDE 112/7/09. E9254

NATIONAL COAL BOARD

NORTHERN (N. & C.) DIVISION

AREA CHIEF ENGINEER (MECHANICAL AND ELECTRICAL)

Applications are invited for the post of AREA CHIEF ENGINEER (MECHANICAL and ELECTRICAL) in No. 4 Area, Northern (N. and C.) Division.

Applicants must possess sound technical qualifications in Mechanical and Electrical Engineering. Experience of boiler plant, air compressors, constructional and development work and electrical engineering as applied to colliery practice is essential.

Salary : £1235 to £1985 per annum, according to qualifications and experience.

Applications, giving date of birth and full details of technical qualifications and experience in chronological order, should be made not later than 15th July, 1953, to the Area General Manager, National Coal Board, Northern (N. and C.) Division, No. 4 Area, Bankfield, Workington, Cumberland. E9305

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THE ENGINEER

JULY 3, 1953

A Report on Refinery Expansion

THE Organisation for European Economic Co-operation has issued its third report on the co-ordination of oil refinery expansion in the O.E.E.C. countries. In the report the committee reviews the developments of the oil refining industry during the course of the last five years and anticipates that the period of growth will be completed during the next two years. European refineries, it is stated, processed about 72 million tons of crude oil in 1952 compared with some 14 million tons in 1947 and by 1954 a further expansion to 94 million tons is expected, in addition to which there will probably be an unused reserve capacity of approximately 12 million tons per annum. The expansion of refining capacity, it is believed, has been stimulated by the coincidence of several factors such as the rising European demand for petroleum products, the need to find outlets for the increased crude oil production of the Middle East, the stringency of foreign currency and the closing of the Abadan refinery in 1951, with the consequent need to fill in the gap. In 1951 consumption of petroleum products by O.E.E.C. countries increased by 9·9 million tons over the previous year and the returns for 1952, at 69·4 million tons, represented an increase of 4 million tons over 1951. The report estimates that consumption will reach an annual rate of 79 million tons in 1954. It is noted that the curve of consumption rose steeply, particularly from 1948 onwards, and that it is now tending to flatten out although it is still rising. However, it is considered that Europe will still have a substantial refinery capacity for export even in 1956. The probable level of consumption cannot be an infallible guide to the proper level of European refining capacity because many of the refineries operate for the world programmes of the international oil companies, but it is pointed out in the report that the exceptional demands made upon European refineries, subsequent to the closure of the Abadan refinery, are unlikely to continue. Therefore, in this third report, the oil committee emphasises that any new refining capacity should be planned with reference to long-term and economic outlets in order to ensure operation at an economic level.

Prospects of the Shipbuilding Industry

ON the motion for the adjournment in the House of Commons on Friday afternoon, June 26th, Mr. Willey, the member for Sunderland North, again raised the question of shipbuilding and stated that the output for last year was the lowest for thirteen years, and that this year shipbuilders had made many complaints regarding steel allocation and the sequence of supplies. In support of his statements Mr. Willey quoted complaints made at a particular shipyard where steel deliveries in 1952 were some 10 per cent short of the allocation and were still short by a similar amount in the first quarter of 1953. Lloyd's returns for 1952 indicated that the tonnage commenced, launched and completed was in each instance less than in the previous year, which, Mr. Willey said, was disturbing since it was not the general position in world shipbuilding. In view of this contraction in shipbuilding and its possible effect upon the industry, he advocated the setting up of a working party at an early date, to review the industry with a view to taking effective steps to maintain a steady level of employment in the shipyards. In reply, the Civil Lord of the Admiralty, Mr. Wingfield Digby, thought that Mr. Willey was too pessimistic and was not doing any service to the industry by spreading alarm. He assured the House that the shipbuilding industry was in a prosperous state with enough orders on the books to provide work for four years. Such a time lag in the delivery dates was a large factor when considering the placing of new orders and he felt that it would be hardly possible to maintain this position permanently. Mr. Digby admitted that shortage of steel had restricted output, but expressed the hope that the position would improve, if not this year, then next. With regard to the level of employment, the Civil Lord of the Admiralty stated that the industry was employing about 160,000 workers, which number was more than at any time since the beginning of 1950. That, he felt, was a satisfactory state of affairs.

The Institute of Sewage Purification

THE annual conference of the Institute of Sewage Purification was held at Torquay from June 23rd to 26th. The conference was opened with a presidential address by Dr. Harold Wilson, of the South African branch of the Institute, and some six papers were presented. In his address, Dr. Wilson expressed his appreciation for being elected president and the honour it conferred upon the South African branch. He spoke of the origin and growth of his branch and went on to describe the qualifications for sewage works management in South Africa and the pupilage scheme for the training of professional and technical workers in Johannesburg. Dr. Wilson said he looked forward to the time when it would be possible to arrange an exchange of workers from South Africa with an equal number from this country. By such exchanges South Africans would have an opportunity to study the immense resources of this country, whilst British workers would see in South Africa how old problems were dealt with in new ways as well as new problems dealt with in old and new ways —sometimes in novel circumstances. The following papers were read during the conference :—" The River Pollution Prevention Officer : An Inquirer and Co-ordinator," by Mr. L. Gill ; " The Problems of an Overloaded Sewage Works," by Mr. F. W. Allen ; " Trends in Digestion of Sludges and Wastes in the U.S.A.," by Dr. W. Rudolfs ; " City of Plymouth Camels Head Sewage Disposal Works," by Mr. J. Paton Watson ; " Sewage Disposal Works of the Borough of Great Torrington," by Mr. A. E. Dyer, and " Recent Sewage Treatment Developments in Germany," by Dr.-Ing. H. Rohde.

Institution of Production Engineers' Conference

THE biennial conference of the Institution of Production Engineers was held this year at Harrogate from June 25th to 28th, and its theme, " Production for Plenty," was designed to strike a note of confidence in the future in contrast to the " work or want " outlook which was considered to have a negative and depressing effect. The conference opened with a dinner on Thursday, June 25th, at which the guest of honour and principal speaker was Viscount Swinton. At the first plenary session the following morning an address was given by the president of the Institution, Sir Cecil Weir, who said that this country required a new outlook which took account of a fresh situation and provided a new stage from which to launch out into new adventures in human progress. He said that we should have to participate in new schemes for the creation of fresh and expanding markets, for the development of new resources, and for the raising of standards of other people so that civilisation might progress and our own standards not be pulled down. At the conclusion of the president's address the conference was broken up into four discussion groups. One group, at which the introductory paper was presented by Mr. R. Ayton, discussed how to encourage an acceptance of individual responsibility directed to production for plenty. Mr. E. Simkin read the first paper before a group discussing how to promote closer collaboration between designer and production engineer to shorten the design/production time cycle. Means by which the need for inspection could be reduced were discussed by another group after a paper by Dr. John Barnett, whilst a discussion on ways of maintaining capital equipment in face of heavy taxation was introduced by a paper by Mr. S. J. Harley. The four discussion groups, which sat in the afternoon, dealt with promoting an objective approach to customer satisfaction, the first speaker being Mr. J. Blakiston ; how production engineers can anticipate future technical developments, the first speaker being Mr. H. Bainbridge ; how the machine tool industry can contribute to production for plenty, the first speaker being Mr. R. Hutcheson, and how to use work study to improve methods, the first speaker being Mr. G. P. Wade. The reports of the discussion groups were presented to the conference on the morning of June 27th and the conference was summed up by Mr. E. W. Hancock.

Dover Car Ferry Terminal

ON Tuesday of this week an official luncheon was held in Dover to inaugurate the entry into service of the new car ferry terminal which is situated in the Eastern Docks. At the luncheon Mr. H. T. Hawksfield, the chairman of the Dover Harbour Board, proposed the toast of " The Minister of Transport and Civil Aviation," during the course of which he welcomed the representatives of the French and Belgian ports, of other bodies both private and national, concerned with transport, and briefly outlined the developments in the Port of Dover since 1606, when James I gave the control of the harbour to the Dover Corporation. The Minister, Mr. Alan T. Lennox-Boyd, briefly replied and, after symbolically cutting the ribbon across the roadway, drove over the loading ramp on to the car ferry T.S.S. " Dinard." He then returned ashore to inspect the marine works and to open the reception building. The terminal was planned after the war to deal with the large volume of accompanied car traffic which is now at an annual rate of about 100,000 cars, and will accommodate four ships making seven arrivals and seven departures daily at and from the terminal. There are two loading berths, each 400ft in length and 72ft in width, formed by widening the existing West Jetty and constructing two additional jetties consisting of concrete dolphins. The head dolphins to each berth are of increased size and equipped with a flexible fender system and there are stern buffer fenders designed to protect the stern of the ships and to damp out movement due to swell. Access to the shore is by a short link span to bridges, 140ft long, hinged at the land end and adjusted in height at the seaward end, to meet the tidal range, by hoisting machinery carried in reinforced concrete portals. Other works consist of a reception building, customs examination building, designed to deal with 240 cars per hour, car park and service station.

Decentralisation of British Railways Administration

(*Contributed*)

One of the principal objects of the Transport Act recently passed is to bring about a decentralisation of the administration of British Railways. The British Transport Commission is called upon to produce a suitable scheme. In this article, contributed by a railway engineer, the history of the administration of railways in Britain in this century is touched upon and suggestions made about the outline of an organisation which might meet the requirements of the new Act.

A GOVERNMENT Bill to amend the Transport Act of 1947 has now received the Royal Assent. With respect to railways one of the principal objects of the new Act is to reorganise the system of administration, abolishing the Railway Executive and calling upon the British Transport Commission to produce a scheme under which the administration is to be decentralised, but at the same time make provision to retain the overall control necessary for the existing unified system of British Railways. As this decision has been taken it is perhaps idle to discuss the reasons which may have led to it ; to many it may seem to be just a political move, but, of course, there is much more to it than that. For instance, during the debate on the Bill in Parliament it was divulged that the British Transport Commission was itself in favour of important modifications which would, in effect, have abolished the Railway Executive, at least in the form in which it now exists. Experience indicates there are good grounds for the opinion that in a large and complex industrial undertaking serving a wide area, a centralised organisation tends to become bureaucratic and out of touch with local opinion and requirements. As ultimate responsibility rests with it, it keeps authority to itself and hesitates to give its local representatives the power to deal with matters of policy lest the action taken by them may be embarrassing.

Whatever advantage it may be visualised should accrue from a " centralised " control, whether by bulk purchase, standardisation, rationalisation, and so on, it would seem that in the administration of large groups of any kind two fundamental principles must be observed.

The first is that at any point in an organisation where operational authority is in the hands of one man who has been given power to act within predetermined limits, it is important that the magnitude of the charge should not be greater than can be controlled by one man in all necessary detail. Secondly, it is essential that the initiative of the man on the spot and his freedom to act should not be sacrificed. Decentralisation thus invariably involves the devolution of authority giving adequate latitude for policy making at least as far as is necessary to meet local needs, yet in other aspects, notably in technical and financial matters, there must be a central authority if the full benefits of a unified railway system are to be obtained.

Before suggesting the outline of an organisation which might meet the requirements of the Act in respect of the decentralisation of railways it is perhaps desirable to recapitulate briefly the main modifications in organisation which changing circumstances have forced on the railways of Britain in the last thirty years or so.

At the conclusion of the first World War there were more than 100 railway companies, many of which were in a precarious financial state, and with the prospect of keen competition from road vehicles the outlook was bleak. In their own interests, therefore, the railway companies agreed to a Government plan for amalgamation and in consequence the grouping of railways into four main groups was carried out in 1923. This was indeed a drastic change, but conformed to a plan which had been worked out carefully under Government auspices by a Minister of Transport who had long practical experience of railways and when framing the scheme worked in the closest consultation with the railway companies. In general, at least, from the point of view of organisation, this amalgamation was a successful arrangement which still retained a healthy element of inter-railway competition ensuring that the public interest would be constantly in the forefront of policy. It might, however, be mentioned in passing that the satisfactory management of the largest of these railway organisations raised many problems, among them the ever-present tendency towards centralised control resulting in the necessity for referring to the top for decision on details which might have been more conveniently settled at a lower level.

The strains and stresses inevitable from the amalgamation of so many component railway companies had scarcely been " normalised " when World War II arrived. To cope with the enormous demand made on them by this catastrophe the railways used all their resources to the utmost, and by the time the war had ended it was clear that the problems involved in the rehabilitation of the railways would be immense. There is some evidence that the managements of the four big railway companies themselves felt that unification was a desirable step, but were of the opinion that this could be done under private ownership. However, at this juncture a new Government came into power, wedded to a policy of nationalisation of basic industries, and as a result the Transport Act of 1947 was passed under which the railways became State property from January 1, 1948. Under this Act the British Transport Commission was set up and, as far as the railways were concerned, the objective as stated by the chairman of the Commission was to unify the British railways system and in doing so to create an organisation which would avoid the danger of undue centralisation and provide adequate machinery for the rapid recognition of local needs, both most excellent precepts. Section 5 of the Act also laid down that under the Transport Commission the various forms of inland transport should each be controlled by a body known as an Executive. One of these was, of course, the Railway Executive. The members of the Executive were appointed by the Minister of Transport in consultation with the British Transport Commission and it might be as well to mention that the Executives exercised only such powers as were delegated to them by the British Transport Commission.

In visualising the task put to the Transport Commission by the Act, and for the purpose of this article, to the Railway Executive in particular, it is important to remember that the railways had to be " unified." In this regard one of the main objects was to take advantage of the opportunities offered by unification for reviewing current methods of working, kinds of equipment, &c., and standardising the best where standardisation was appropriate. It was probably for this reason more than any that the Commission decided that the Railway Executive should work on a " functional " basis, i.e. that each of the six full-time members (excluding the chairman) should exercise functional responsibilities over the whole railway system, and provided that these functional members could deal direct with their functional counterparts at each of the regional headquarters on technical and departmental matters. From the outset this functional organisation was strongly criticised, principally on the grounds that it dispensed with " regional management " and left the chief regional officer in an anomalous position. It was argued that the channel of communication would largely by-pass him, with the result that he would become a figurehead and that as a further consequence the Railway Executive would become bogged down in a mass of business much of which could and should be equally well dealt with at regional level. At the time of unification, however, there were undoubtedly very sound reasons for introducing the " functional executive " system of management, particularly in view of the Government decision that the railways had to be unified—the operative word ! It would have been a very protracted if not impossible task to " unify " the " big four " by a process of mutual agreement ; an element of dictatorship was necessary.

Nevertheless, there are indications that what seems to be the inevitable tendency of functional organisations, namely, to become over-centralised, has also occurred with the Railway Executive. This is emphatically not to decry the really splendid work which has been done by that Executive in little more than five years under the most disheartening circumstances. Starved of capital, faced with a chronic shortage of basic construction materials, with an enormous increase in the cost of such of these as could be obtained, with a large increase in labour rates and with interference and revilings from many who had no conception of the difficulties involved, the many and varied problems have been boldly tackled, progressive policies have been hammered out and steadily implemented.

Unification has been achieved. It will remain ; but there is now felt to be a need for greater flexibility in the organisation. To accomplish this, it has been decided that administration should be effectively decentralised and the Act calls for the British Transport Commission to submit to the Minister of Transport within one year a scheme to ensure this. The Minister will consult upon it with interested parties, especially those representing industry and trade, and the scheme is to be submitted to Parliament in the form of a White Paper. The plan will at least have the merit of being prepared by men familiar with railway problems and the ramifications of railway organisation, but a piquant situation will arise if, as a result of the consultations referred to and a debate in Parliament, modifications are made to the scheme which are unacceptable to the British Transport Commission.

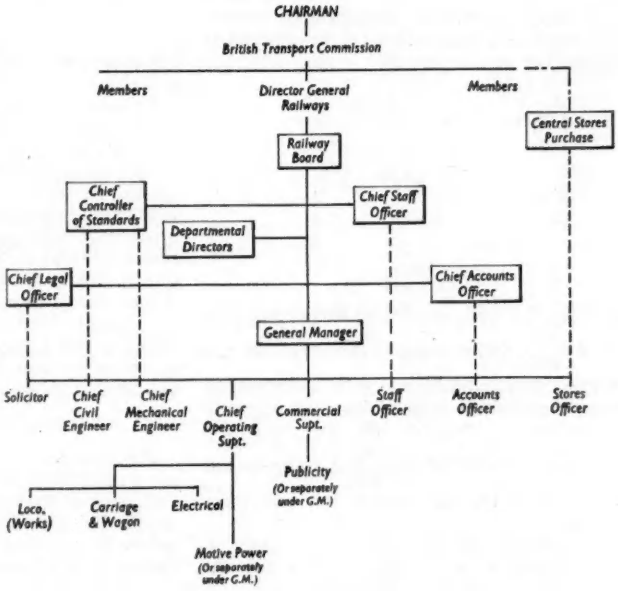
The position is therefore a very indeterminate one, and the time would appear appropriate for the submission of ideas on

the matter of railway organisation, which might meet the conditions contained in the Act. For this purpose it would seem to be a good line of approach to take as a guide an organisation which has had to deal with problems similar to that of the British Transport Commission in relation to railways, and which worked satisfactorily over a long period. It is suggested that such an organisation was to be found in the administration of railways in India—at least, as this functioned prior to the transfer of power from the British Government to the separate Governments of India and Pakistan. The writer is not familiar with modifications which may have been made since that event.

At the head of the organisation of Indian Railways there was a Railway Board consisting of a Chief Railway Commissioner and four members. There was also a Financial Commissioner. The members of the board were experienced railway administrators and the board made joint decisions on matters of major policy. The Chief Railway Commissioner also represented railway matters in the Legislative Assembly. Under the Railway Board were officials known as directors, who were in charge of departmental matters, e.g. civil engineering, mechanical and electrical engineering, transportation, stores, establishment, accounts, &c. All matters connected with design were dealt with by a Controller of Standardisation, whose status might be described as being between that of a member of the board and one of the departmental directors. Each railway (or region) had a general manager who exercised an authority over his railway similar in nature and degree to that of a general manager of a former British railway company. He prepared capital budgets for his own railway (usually in the form of a triennial programme) and also the annual revenue budget; these budgets after consideration and approval by the Railway Board were then operated by him. Communications from the Railway Board to the various railways were addressed to the general manager, who passed on instructions as necessary to his principal officers. Similarly, the views of the latter were reported to the Railway Board by the general manager. He was therefore the one authority for his particular railway and there was no question of divided loyalties among the officers subordinate to him. As will be seen, this organisation was very simple and had one great advantage, that each principal officer on the railway had only one " boss," i.e. his general manager.

The organisation outlined above transposed to show a similar relationship between the British Transport Commission and the British Railways is represented diagrammatically, in " tree " form, above.

There was, however, an important factor which was perhaps unusual in view of the influence both on policy making and its implementation. Outside the organisation described, but very closely integrated with it, as its members were all railway personnel, was another body known as the Indian Railway Conference Association (I.R.C.A.). This association developed from conferences which were for many years held by the Loco and Carriage Superintendents Standards Committees; these were very successful in pioneer work connected with design and standardisation and apparently pointed the way for adoption by other branches. The Indian Railway Conference Association was established by the several railway administrations in the days when some were partly company owned and managed whilst others were wholly State-owned and managed. It was found that differences in outlook and policy were much more rapidly and satisfactorily solved through meeting and talking things over than by correspondence. It also proved an excellent medium for the exchange of ideas on an unofficial plane and gradually the I.R.C.A. comprised sections representing all the main branches of railway activity.



Dotted lines show communication for policy (or design) matters only.

The organisation shown is for one railway (region) only, under its general manager. The remaining regions would, of course, have similar organisations.

Suggested Railway Organisation

The personnel of each section of the Association was composed of the appropriate principal officers of each of the important railways; each section met as necessary, usually twice yearly. Matters for discussion were put forward by the various railway administrations, some of which may have been prompted by the Railway Board itself, and the pros and cons of each proposal were discussed. Where necessary, as for example in the carrying out of experiments, it was usual to recommend an appropriate railway administration to be responsible for them and to act as a reporter. Railway Board officers were also present during the conference meetings, holding a watching brief and directly or indirectly referred matters to the conference for discussion. Resolutions of the conference were submitted to the Railway Board, which issued official directives based on these resolutions, which then became operative. Thus, although the final decision was with the Railway Board, it can be appreciated that the conference furnished it with a very useful picture of railway activity and the reaction of the various railway systems to common problems. In addition, as the top men in any particular aspect of railway work were assembled together for these discussions it assisted those responsible for selecting officers for the highest administrative grades to determine the most suitable man for the job.

The advantages of being able to discuss new ideas and experiences on an unofficial basis such as was afforded by the I.R.C.A. can scarcely be over-emphasised. It provided an excellent two-way channel for the consideration of new proposals; whether they came from the Board or from an individual railway administration and they proved a most useful method of arriving at a satisfactory and generally accepted policy. The I.R.C.A. arrangement might be thought to be analogous to that of the Railway Clearing House Committee system operating in Great Britain, but there was perhaps a vital difference in that if there were dissentients from certain resolutions the matter did not rest there as there was the central authority to give a decision.

In conclusion, returning to the structure of the existing railway organisation, it is felt to be fair criticism to say that in general it resembles too closely a Civil Service chain of administration. Although the method of selection and training of Civil Servants for the administrative class is possibly excellent for the duties of that service, it does not follow that such a method produces the men with the outlook necessary for the successful management of a large industrial organisation. In fact, the requirements are fundamentally different. The senior Civil Servant is essentially concerned with memoranda, statistics and the skilled handling of State papers. The industrial manager on the other hand is concerned with getting results. He must know how to handle men; he must have a business instinct and as he has to deal with the economical use of equipment of considerable capital value he often needs an engineering instinct also. He has to have the knowledge and ability to take decisions and not think in the terms of writing notes to persuade others to accept responsibility.

If the present organisation of railways continues for long there would seem to be a real danger that it will develop a class of administrator hesitant in accepting responsibility. Any such conditioning of mind is also bound to inhibit the spirit of progress. So it is to be hoped that the scheme of decentralisation ultimately to be implemented will clearly show that real power has been delegated to those officers who are to be held responsible for the management of the various " geographical areas " of British Railways.

NATIONAL POWER FARMING CONFERENCE.—The fourth National Power Farming Conference is to be held at the Town Hall, Cheltenham, on February 9, 10 and 11, 1954. It will be organised by the *Power Farmer*.

RESEARCH ON THE CONSERVATION OF RAW MATERIALS.—Research organisations in Great Britain and the principal European countries are working on the problems of conserving such raw materials as metals, fuels, chemicals and textiles which are scarce. The work being done includes the discovery of methods of economising in the use of the materials, the provision of adequate substitutes, the recovery of waste materials, and the protection of materials liable to be attacked by corrosion or decay. As it is not always easy for an inquirer on these subjects to discover all the sources of information on the problem in which he is interested, a list of sources has now been collected by the Sub-Committee for Co-operation in Scientific Research and Technical Development of the O.E.E.C. The information available covers work being done in Austria, France, Germany, Italy, the United Kingdom, and Sweden. The list consists of standard sheets, and we are informed that the sheets can be consulted at, or borrowed from, the Technical Information and Documents Unit, D.S.I.R., at Cunard House, 15, Regent Street, London, S.W.1.

Some Notes on Plane Frames Not Obeying Hooke's Law

By J. W. H. KING*

The normally accepted laws of analysis for plane frames may become invalid if any members of the frame do not behave according to Hooke's law. A discussion of the analysis of such frames is given below, with examples of the analysis of a cantilever girder whose members follow the same non-linear stress-strain curve.

NON-LINEARITY of the load/extension curve for any member of a plane frame may be due to a variety of causes, the chief ot which are : stressing beyond the yield point into the plastic range ; non-linearity of the stress/strain curve for the material used ; and buckling and/or initial curvature of members. When any such members are present in a frame it will be found that many of the normally accepted laws of analysis are probably invalid, the chief ones liable to be affected being :

(1) Clerk Maxwell's reciprocal law ;
(2) The principle of superposition ;
(3) Castigliano's theorems—or any comparable strain energy method of analysis ;
(4) The properties of influence lines which allow a diagram indicating the effect of a single unit point load to be used for more complex loading systems.

In addition the order of applying loads may now be of importance, particularly where stress reversal is introduced, after the members have been stressed into the plastic range. Furthermore, it is no longer possible to determine the effect of the prop, in a propped cantilever, by considering separately the downward deflection of the propping point due to the imposed loads, and the upward deflection of the same point due to the prop, and equating the difference to the initial lack of fit, even though there has not been plastic straining, provided, at some stage in the analysis, one or more members have departed from a strictly constant load/extension ratio.

Where analysis does not involve strain, but only the geometry of the frame, the normal laws hold, provided the strained shape of the frame is materially the same as its initial shape. For instance, non-redundant frames can be analysed in the normal way, by force polygons, or the method of sections. It follows from the latter that if one considers rotations of sections of frame about appropriate points, instead of taking moments about them, taking care to fulfil the necessary conditions of no movement at supported points, one will obtain the same ratio between change of length of any member, and displacement of a joint, as one obtains between load applied at the joint and load induced in the member. This important fact enables one to solve, comparatively simply, many of the plane frame problems which become impossible by normal methods when Hooke's law ceases to operate, and is used to obtain the terms R^1 and S^1 in the analyses below.

Deflection of Frames

It is unfortunate that a preoccupation with mathematics has tended to cloud the real significance of what is usually known as Castigliano's First Theorem. This usually states that the differential of the strain energy of a system with respect to an external load W gives the deflection of the loaded point. One of the easiest proofs of this first theorem connects the deflection Δ to the extension of the individual members, as $\Delta=\Sigma\delta\frac{\partial P}{\partial W}$, where δ is the extension of any member, and $\frac{\partial P}{\partial W}$ the load induced in it by unit load at W, when unaffected by any redundancies. It is unfortunate that by subsequently changing δ to $\frac{Pl}{aE}$ the mathematicians were able to show the expression to be the same as $\frac{\partial}{\partial W}\left(\Sigma\frac{P^2l}{2aE}\right)$ —a purely fortuitous circumstance, which has exercised a great effect on the analysis of redundant structures ever since, and has

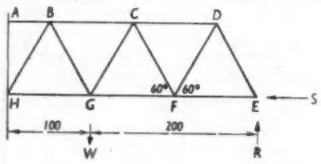


Fig. 1

clouded the really important earlier fact that $\Delta=\Sigma\delta\frac{\partial P}{\partial W}$. By returning to this stage one can handle many problems with comparative ease, since a knowledge of the load/extension curve for any member will give δ for any known or assumed P, and $\frac{\partial P}{\partial W}$ is a constant at all times if the structure is not materially distorted.

A number of examples of solutions to typical problems are given below for the cantilever girder of Fig. 1. To simplify the working the girder is assumed to have all members of area $=\frac{1}{\sqrt{3}}$ square inch and all obeying the stress/strain relationship of Fig. 2 both in tension and compression. Most of the working is shown in tabular form in Tables I to III. Only such members and columns are included in the tables as affect the answer—e.g., only those members giving

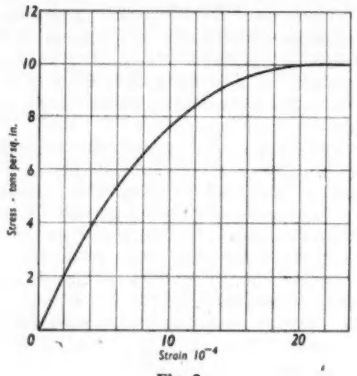


Fig. 2

rise to entries in columns 7 and 8 are included in Table I.

Problem 1.—To determine the deflection of the point E, when $R=S=0$ and $W=5$ tons, or 2·5 tons.

The solution is carried out in Table I and should be clear from the above notes. It will be seen that not only do the vertical and horizontal deflections of E bear no fixed relationship to W, but also they bear none to one another. A slight increase in W beyond 5 tons would increase the vertical deflection very greatly (in fact, to collapse) whilst not affecting the horizontal deflection except in so far as the complete collapse of the frame would alter its geometry.

Redundant Frames

Problem 2.—To determine the reaction R on a rigid prop at E preventing any vertical deflection of that point when $W=5$ tons and $S=0$. It is assumed that the prop is in place before W is applied, and that as a consequence the loads in all members build up gradually

Table I

	For $W=5$ tons								For $W=2·5$ tons			
Column No. ...	1	2	3	4	5	6	7	8	3	4	7	8
Quantity	l	P	p	e	R^1	S^1	R^1le	S^1le	p	e	R^1le	S^1le
Units	Ins	Tons/$\sqrt{3}$	Tons/in²	10^{-4}	$1/\sqrt{3}$	1	$\frac{\text{In}}{100\sqrt{3}}$	$\frac{\text{In}}{100}$	$\frac{\text{Tons}}{\text{in}^2}$	10^{-4}	$\frac{\text{In}}{100\sqrt{3}}$	$\frac{\text{In}}{100}$
AB	50	−10	−10	−20	6	0	− 60	0	−5	−5·8	−17·4	0
HG	100	5	5	5·8	−5	1	− 29	5·8	2·5	2·6	−13·0	2·6
BH	100	10	10	20	−2	0	− 40	0	5	5·8	−11·6	0
BG	100	−10	−10	−20	2	0	− 40	0	5	−5·8	−11·6	0
						Σ	−169	5·8		Σ	53·6	2·6

Hence for $W=5$ tons, E deflects $\frac{169}{100\sqrt{3}}=0·98$in down and 0·058in left,

whilst for $W=2·5$ tons, E deflects $\frac{53·6}{100\sqrt{3}}=0·31$in down and 0·026in left.

The full headings of the columns in Tables I to III are as follows, the units used being specified in the table headings :

Column 1 : l=length of member in inches.
Column 2 : P=load in member due to stated values of W, R and S.
Column 3 : p=stress in member (compression + *ve*).
Column 4 : e=strain in member, deduced from Fig. 2 (compressive + *ve*).
Column 5 : $R^1=\frac{\partial P}{\partial R}$=ratio of resulting deflection of R to compression of member.
Column 6 : $S^1=\frac{\partial P}{\partial S}$=ratio of resulting deflection of S to compression of member.
Column 7 : R^1le=product of columns 1, 4, 5. Sum=upward deflection of $E=\Delta_R$.
Column 8 : S^1le=product of columns 1, 4, 6. Sum=leftward deflection of $E=\Delta_S$.
Column 9 : $\frac{\partial e}{\partial p}$=Reciprocal of slope of p/e curve of Fig. 2 at stress shown in column 3.
Column 10 : $A=\Sigma$(product of columns 1, 5, 5, 9÷area of member).
Column 11 : $B=\Sigma$(product of columns 1, 5, 6, 9÷area of member).
Column 12 : $C=\Sigma$(product of columns 1, 6, 6, 9÷area of member).
Columns headed 2*a*, 3*a*, &c., are as 2, 3, &c., using revised values of redundant forces R, S, &c., as shown.

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to their final values without stress reversal at any stage.

It is clear that any small change δR in the value of R would alter the load in a member by $\delta R \,.\, R^1$. Its compression would then be altered by an amount $\dfrac{\delta R \,.\, R^1 \,.\, l \,.\, \partial e}{a \,.\, \partial p}$, where a is the area of the member, and the other terms have the significance given above. This would lead to a change in ΔR the deflection at E in the vertical direction of R, of $\delta R\left(\dfrac{(R^1)^2 \,.\, l \,.\, \partial e}{a \,.\, \partial p}\right)$, which, being summed for all members, gives the value $A \,.\, \delta R$ (see column 10 explanation above). Hence, provided an initial value of R is assumed which is in the region of the correct value, for cases where the initially assumed R was very much out. The trial value of R was obtained by taking a round figure of about 50 per cent of the value of R if member AB were absent. This was 1 ton. The subsequent correction was only 0·08 tons, giving the final R=1·08 tons. As a matter of interest, the deflection of E vertically due to 1·08 tons at R alone has been calculated. It amounts to 0·67in, as against 0·98in for W alone, thus illustrating the impossibility of using the normal methods of solution by balancing out deflections due to forces taken separately.

Problem 3.—To determine the reaction of a hinge at E, which permits rotation but no other motion, when W=5 tons. In this case it is necessary to determine two force components, conveniently taken as R and S.

A similar argument to that above indicates that small changes in R and S, of δR and δS, would alter the force in any member by $R^1\delta R + S^1\delta S$, and would therefore result in total deflection changes at E of $R^1\times$(the sum of the resulting compression changes) vertically upwards, and $S^1\times$(the same values) leftwards. Thus if we assume an R and an S, and calculate Δ_R and Δ_S, we can obtain corrections δR and δS by solving the equations

$$\delta R \,.\, A + \delta S \,.\, B + \Delta_R = 0$$
$$\delta R \,.\, B + \delta S \,.\, C + \Delta_S = 0$$

where A, B and C have the significance shown in the above explanations of columns 10, 11, 12.

Hence

$$\delta R = \frac{B \,.\, \Delta_S - C \,.\, \Delta_R}{AC - B^2}$$

and

$$\delta S = \frac{B \,.\, \Delta_R - A \,.\, \Delta_S}{AC - B^2}$$

Table III gives the first approximation to the solution and shows no further approximation to be necessary. The initial value of R was assumed as for problem 2, whilst S was chosen as $1\cdot5/\sqrt{3}$ to give a reasonably round figure stress value about equal and opposite to the mean value in HE resulting from W and the assumed R. Although these were both quite well out, the first correction proved to be all that was necessary for obtaining the final solution.

Conclusion

In all the above problems it has been assumed that member loading was not reversed by the application of the external loads. Where the stress/strain curve, although not linear, is still within the elastic range throughout, the effect of reverse loading can be found by tracing backwards along the curve. Clearly in this case the final effect is the same as obtained by gradually loading as far as the final value. In most cases, however, unloading results in retracing a new curve and the formation of a hysteresis loop. In such cases it is necessary to find the deflections resulting at intermediate stages and to follow out new stress/strain curves between stages, which are appropriate to the members concerned both as regards stress change and stress range. Although the work is much more tedious, it is intrinsically the same as that carried out above and follows the same general laws. Incidentally, referring to the end of problem 2,

Table II

Column No.	1	2		3	4	5	7	9	10	2a		3a	4a	7a
Quantity	l	P due to W=5	P due to R=1	p	e	R^1	R^1le	$\frac{\partial e}{\partial p}$	$\frac{(R^1)^2 l \partial e}{a \,.\, \partial p}$	P due to W=5	P due to R=1·08	p	e	R^1le
Units	In	Tons/$\sqrt{3}$		ton/in²	10^{-4}	1/$\sqrt{3}$	In/100$\sqrt{3}$	$\frac{10^{-4}}{\text{Ton/in}^2}$	$\frac{\text{In}}{100\sqrt{3}\text{ tons}}$	Ton/$\sqrt{3}$		Ton/in²	10^{-4}	In/100$\sqrt{3}$
AB	50	−10	6	−4	−4·4	6	−13·2	1·3	23·4	−10	6·48	−3·52	−3·7	−11·1
BC	100	0	4	4	4·4	4	17·6	1·3	20·8	0	4·32	4·32	4·8	19·2
CD	100	0	2	2	2·0	2	4·0	1·0	4·0	0	2·16	2·16	2·2	4·4
HG	100	5	−5	0	0	−5	0	1·0	25·0	5	−5·40	−0·40	−0·4	2·0
GF	100	0	−3	−3	−3·1	−3	9·3	1·1	9·9	0	−3·24	−3·24	−3·4	10·2
FE	100	0	−1	−1	−1·0	−1	1·0	1·0	1·0	0	−1·08	−1·08	−1·1	−1·1
BH	100	10	−2	8	11·0	−2	−22·0	2·0	8·0	10	−2·16	7·84	10·8	−21·6
BG	100	−10	2	−8	−11·0	2	−22·0	2·0	8·0	−10	2·16	−7·84	−10·8	−21·6
CG	100	0	−2	−2	−2·0	−2	4·0	1·0	4·0	0	−2·16	−2·16	−2·2	4·4
CF	100	0	2	2	2·0	2	4·0	1·0	4·0	0	2·16	2·16	2·2	4·4
DF	100	0	−2	−2	−2·0	−2	4·0	1·0	4·0	0	−2·16	−2·16	−2·2	4·4
DE	100	0	2	2	2·0	2	4·0	1·0	4·0	0	2·16	2·16	2·2	4·4
						Σ	47·9−57·2 = −9·3	Σ	116·1				Σ	54·5−54·3 ≈0

To accuracy of calculations

∴ Approximate $\delta R = \frac{9\cdot3}{116\cdot1} = 0\cdot08$ tons.

Hence new value for R=1·08 tons. Checked as correct in columns headed "*a*."

Table III

Column No.	1	2			3	4	5	6	7	8	9	10	11	12	2a			3a	4a	7a	8a
Quantity	l	P due to W=5	R=1	S=0·866	p	e	R^1	S^1	R^1le	S^1le	$\frac{\partial e}{\partial p}$	$(R^1)^2 \frac{l}{a}\frac{\partial e}{\partial p}$	$\frac{R^1S^1l\cdot\partial e}{a\cdot\partial p}$	$\frac{(S^1)^2l\cdot\partial e}{a\cdot\partial p}$	P due to W=5	R=1·24	S=1·19	P	e	R^1le	S^1le
Units	In	Ton/$\sqrt{3}$			$\frac{\text{Ton}}{\text{in}^2}$	10^{-4}	1/$\sqrt{3}$	1	In/100$\sqrt{3}$	In/100	$\frac{10^{-4}}{\text{ton/in}^2}$	$\frac{\text{In}}{100\sqrt{3}\,t'ns}$	$\frac{\text{In}}{100\text{ tons}}$	$\frac{\sqrt{3}\text{in}}{100\text{ tons}}$	Ton/$\sqrt{3}$			$\frac{\text{Ton}}{\text{in}^2}$	10^{-4}	In/100$\sqrt{3}$	In/100
AB	50	−10	6	—	−4	−4·4	6	—	−13·2		1·3	23·4	—	—	−10	7·44	—	−2·56	−2·6	−7·8	
BC	100	—	4	—	4	4·4	4	—	17·6		1·3	20·8	—	—	—	4·96	—	4·96	5·7	22·8	
CD	100	—	2	—	2	2·0	2	—	4·0		1·0	4·0	—	—	—	2·48	—	2·48	2·5	5·0	
HG	100	5	−5	1·5	1·5	1·5	−5	1	−7·5	1·5	1·0	25·0	−5·0	1·0	5	−6·20	2·07	0·87	0·9	−4·5	0·9
GF	100	—	−3	1·5	−1·5	−1·5	−3	1	4·5	−1·5	1·0	9·0	−3·0	1·0	—	−3·72	2·07	−1·65	−1·7	5·1	−1·7
FE	100	—	−1	1·5	0·5	0·5	−1	1	−0·5	0·5	1·0	1·0	−1·0	1·0	—	−1·24	2·07	0·83	0·8	−0·8	0·8
BH	100	10	−2	—	8	11·0	−2	—	−22·0		2·0	8·0	—	—	10	−2·48	—	7·52	10·0	−20·0	
BG	100	−10	2	—	−8	−11·0	2	—	−22·0		2·0	8·0	—	—	−10	2·48	—	−7·52	−10·0	−20·0	
CG	100	—	−2	—	−2	−2·0	−2	—	4·0		1·0	4·0	—	—	—	−2·48	—	−2·48	−2·5	5·0	
CF	100	—	2	—	2	2·0	2	—	4·0		1·0	4·0	—	—	—	2·48	—	2·48	2·5	5·0	
DF	100	—	−2	—	−2	−2·0	−2	—	4·0		1·0	4·0	—	—	—	−2·48	—	−2·48	−2·5	5·0	
DE	100	—	2	—	2	2·0	2	—	4·0		1·0	4·0	—	—	—	2·48	—	2·48	2·5	5·0	
								Σ	42·1−65·2 = −23·1	2·0−1·5 =0·5	Σ	115·2 =*A*	−9·0 =*B*	3·0 =*C*				Σ	52·9−53·1 ≈0	1·7−1·7 =0	

$$\delta R = \frac{-9\sqrt{3}\times0\cdot5\sqrt{3}+9\times23\cdot1}{9\times115\cdot2-(9\sqrt{3})^2} = \frac{207\cdot9-13\cdot5}{1036\cdot8-243} = \frac{194\cdot4}{793\cdot8} = 0\cdot243 \text{ tons.}$$

$$\delta S = \frac{9\sqrt{3}\times23\cdot1-115\cdot2\times0\cdot5\sqrt{3}}{793\cdot8} = \frac{\sqrt{3}(207\cdot9-57\cdot6)}{793\cdot8} = \frac{150\cdot3\sqrt{3}}{793\cdot8} = 0\cdot328 \text{ tons.}$$

∴ First approximate values for R and S are 1·243 and 1·194 tons ≈1·24 and 1·19 tons.

Hence to accuracy of working R=1·24 tons and S=1·19 tons.

assessing p and $\partial e/\partial p$, changes in Δ_R can be assessed reasonably as $=A \,.\, \delta R$.

The method of solution resulting is as follows. By more or less intelligent guesswork, assess a value for R and work out Δ_R for the combined effect of W and R. Ascertain A, using the assumed values of p to obtain $\partial e/\partial p$. Then $A \,.\, \delta R + \Delta_R$ = initial lack of fit very nearly, =0 in this instance, whence δR the correction to be applied to the assumed R can be found.

Table II carries out the complete solution, together with a check on the new value of R. This is seen to be correct to the accuracy worked to. Less accurate values of δR are likely to result if $\dfrac{\partial e}{\partial p}$ for any member is changing rapidly in the region of the actual p obtained or assumed, and a second approximation may be called for in such cases, or in

it should be noted that, whilst a force of 1·08 tons at *R* only deflects *E* by 0·67in when applied to the unloaded frame, it would deflect it by the necessary 0·98in required for equilibrium if applied to the frame already deflected by 5 tons at *W*, provided the original stress/strain curve still held good in reverse.

It may be observed that had *W* slightly exceeded 5 tons, problem 2 could have had many different solutions if treated as a two-stage problem, since several members would have been stressed beyond 10 tons per square inch into a plastic range on applying *W*. The extent of deformation permitted would then have had a material effect on the *R* required to restore *E* to its original position. In actual fact, of course, the stresses do not approach this figure until *W* is considerably greater than 5 tons.

Where the proper sequence of analysis clearly leads to full plastic yield of a member the obvious course of action is to remove it from the analysis and replace it by end forces equal to its yield load. Each time this can be done safely, results in the removal of one redundancy from the analysis. Where no redundancies exist, or where none are affected by such a removal, the frame will clearly collapse when such a member reaches its yield load, and further analysis would be pointless.

The Influence of Fuel Gas on the Spraying of Metal Powders

By WILLIAM McDERMOTT, B.Sc.,* and ROBERT DICKINSON, M.Sc.*

The principles involved in the spraying of powdered metals are outlined indicating that almost any combustible gas may be used as a source of heat to melt the powder particles. The use of acetylene, methane, propane, butane, natural gas, coal gas, enriched coal gas, and enriched propane, for metal spraying is discussed, the chemical reactions in the flames are described, and a hypothesis is advanced to explain why gases with widely different physical properties produce similar results. Enriching propane or coal gas with the additives tested is shown to offer no advantages, and brings about only an increase in the processing costs. Tables are included illustrating the relative costs of gases when spraying zinc and aluminium, and coal gas without additives is placed in a position superior to any other fuel gas for the spraying of powdered metals with melting points below 1000 *deg. Cent.*

THE metal spraying process is too well known to require any detailed description in this article, which is concerned with examining the influence of the type of combustible gas used for heating the stream of powder particles. However, it may be useful to indicate the principles involved.

A stream of powdered metal, of suitable particle size, is fed at a predetermined rate through a hot zone produced by the combustion of a fuel gas with oxygen. The particles melt and are picked up by a subsidiary high-velocity air stream, and are deposited with great momentum on to the surface to be coated.

Since most molten metals are easily oxidised it is preferable that the flame should be neutral or slightly reducing, but other properties of the flame are important in ensuring that satisfactory sprayed metal deposits are produced.

The criterion of acceptability for the coating is based on a combination of adhesion, solidity and purity of the deposit. These properties are dependent upon the flame characteristics as will be shown later in this paper. The authors consider that the following minimum values should be attained before a zinc or aluminium sprayed coating can be accepted as satisfactory. Greater values than these are normally obtained commercially :

Adhesion	500 lb per square inch
Solidity	85 per cent

The oxide content should be kept at a minimum, and, in any case, not more than 1 per cent.

Almost any combustible gas may be used for metal spraying, the most commonly used being acetylene, propane, coal gas, methane, butane, Calor gas, enriched propane, enriched coal gas and natural gases. The first three gases listed are most generally used in the metal spraying industry.

THEORY

For spraying metal in powder form many kinds of flame can be employed because of the fact that the flame does not have to function as an atomiser as well as a sprayer of the metal. The powder requires heating to its melting point before it is deposited under neutral or slightly reducing conditions. The flame efficiency in metal spraying, i.e. the percentage of heat utilised to melt the powder, is of the order of about 2 per cent of the heat input.

Since the metal particles start to travel through the flame at the velocity of 200ft to 250ft per second, and the rate of heat transfer to the particles is low, a relatively high temperature flame is required. It may appear that the higher the flame temperature, then the more efficient would be the flame, but this is not true. Take, for example, an oxy-acetylene flame with a temperature of 3270 deg. Cent., an oxy-coal gas flame with a temperature of 2000 deg. Cent., and an oxy-propane flame with a temperature of 2980 deg. Cent. The combustion velocity of the first two combinations is high, while that of the last is low, so, in the case of acetylene and coal gas, the burning area is small, resulting in a short visible flame for these two gases. The propane flame is longer, with a temperature between the other two.

From this it would appear that propane should be the best gas to use since the particles are moving through a longer hot zone than in the case of coal gas or acetylene, but another factor plays an important part—that is, the volume of the products of combustion and their temperature. If a relatively large quantity of combustion products at an adequate temperature is released, this also produces satisfactory spraying conditions.

The volume of the products of combustion depends upon the volumes of the reactants and upon the chemical reaction in the flame. All these factors will be studied individually as each gas combination is discussed, but it is a fact that an oxy-coal gas flame produces a very large volume of combustion products, and the metal particles remain in this hot stream for most of the time they are travelling to the surface to be coated. The temperature is relatively low, but sufficient to prevent the particles from resolidifying before they reach the surface.

From this brief discussion it is evident that numerous gas combinations can be used. The economics of the process depend upon the cost per unit of the gas, and the quantity of gas required to allow an acceptable coating to be produced.

ACETYLENE

In order to promote maximum speed of reaction in the flame and minimise the visible flame length it is necessary in the case of any gas to mix it with oxygen before allowing it to issue from the pistol nozzle. It is also desirable to produce a neutral or reducing flame and from Table I it can be seen that the best flame conditions are obtainable when the oxy-acetylene ratio is less than 1·5 to 1·0 :

TABLE I—*Properties of the Oxy-Acetylene Flame*

$O_2 : C_2H_2$	Flame condition	Number of B.Th.U. liberated per lb mol.	Flame temperature, deg. Cent.
0·8 : 1·0 ...	Reducing	173,000	3,066
0·9 : 1·0 ...	Reducing	184,000	3,149
1·0 : 1·0 ...	Neutral	195,000	3,232
1·5 : 1·0 ...	Oxidising	250,000	3,427
2·0 : 1·0 ...	Oxidising	275,000	3,375
2·5 : 1·0 ...	Oxidising	288,000	3,315

The values are based on the combustion of 26·02 lb, or 1 lb mol. of acetylene. (From Slottman and Roper in *Oxygen Cutting*, published by McGraw-Hill Book Company, Inc.

If the flame condition were not the important factor, as in welding and oxy-gas cutting, the best flame efficiency is obtained at a ratio of 1·7 oxygen to 1·0 acetylene. In the case of the Schori Model 50 powder spraying pistol the quantities of gases per hour, for aluminium spraying, are 60 cubic feet of oxygen and 56 cubic feet of acetylene. This gives a ratio of 1·07 to 1·0 which renders the flame neutral at a temperature of approximately 3270 deg. Cent. The combustion of acetylene is an exothermic reaction, so more heat is released than would be calculated from the carbon and hydrogen contents.

The calorific value of acetylene is 1500 B.Th.U. per cubic foot so the heat input in the case of aluminium spraying is 56×1500 B.Th.U.$=84{,}000$, or 0·84 therm per hour.

This is the lowest heat input for any of the common gases, the others being approximately 50 per cent higher, so acetylene is materially the most efficient fuel gas. However, considering the economics of the process, acetylene costs three to eight times as much per therm as any of the other common gases and is the least economical. Table II gives the cost per therm of some gases, based on present-day prices :

TABLE II—*Cost per Therm of Some Gases used in the Metal Spraying Industry*

Gas	Calorific value, B.Th.U. per cu ft	Price per 1000 cu ft	Cost per therm
		£ s. d.	d.
Acetylene	1500	7 7 6	118·0
Propane	2520	3 14 0	35·2
Coal gas	500	6 0	14·4
Methane	1011	2 10 0	59·3
Ferrogas* (3·0 per cent additive)	550	18 6	40·5

* Ferrogas is a trade name for coal gas enriched by the Oxy-Ferrolene Company, Ltd., Leicester.

The generally accepted reaction in the flame is :

$$2C_2H_2 + 5O_2 = 4CO_2 + 2H_2O$$

Two volumes of acetylene equals six volumes of combustion products, or 56 cubic feet of acetylene equals 168 cubic feet of combustion products. This is the smallest volume of products of combustion for any of the usual gases. However, in the case of metal spraying the very high flame temperature compensates for this, and the metal particles are well

* Schori Metallising Process, Ltd., London.

above their melting point when they pass from the heating cone, so they can afford to lose an appreciable quantity of heat before they strike the surface to be coated. It is obvious, therefore, that in order to prevent oxidation it is advisable to maintain reducing conditions in the acetylene flame.

It is characteristic of acetylene, as with hydrogen, that a small intensely hot zone is produced when it is burnt with oxygen. This is due to what is variously called combustion velocity, flame velocity, speed of reaction, &c., and Table III is a compilation of figures taken from various authorities for the rate of flame propagation in air :

TABLE III—*Flame Velocities of Common Gases in Air*

Gas	Flame velocity, cm per sec.	Per cent gas in air
Hydrogen	267	42·0
Acetylene	131–157	10·0 to 10·7
Propane	45·9	4·6
Butane	45·9	3·4
Methane	37·0	10·5

The flame velocity in oxygen would be proportionately higher and it is for this reason that oxy-acetylene is the generally accepted gas combination for welding and deep cutting. This characteristic is further illustrated in Table IV, which gives the relative flame lengths and flame spreads for common gases. In the case of powder metal spraying the subsidiary air stream affects the relative flame lengths and flame spread to a considerable extent :

TABLE IV—*Flame Lengths and Flame Spreads Relative to Hydrogen which is Taken as Unity*

Gas	Flame length	Flame spread
Hydrogen	1·00	1·00
Coal gas	1·03	0·68
Acetylene	1·025	1·36
Propane	2·35	1·70 to 2·00

(The values are calculated from results quoted at the third Symposium on Combustion, Flame, and Explosion Phenomena held in the University of Wisconsin, U.S.A., and published under the auspices of the Standing Committee on Combustion Symposia in 1949 by the Williams and Wilkins Company, Baltimore.)

Acetylene is supplied dissolved in acetone in various sizes of cylinders, but a great disadvantage with this gas lies in the fact that a large cylinder contains only 200 cubic feet and at a consumption rate of 56 cubic feet per hour, which is the recommended maximum output from a single cylinder of this size, each cylinder would only last for approximately three and a half hours. Each operator thus requires two cylinders per day and in a metal spraying shop with four pistols in operation, approximately forty cylinders per week would be required. Acetylene generators may be used, with attendant difficulties, provided they deliver pure, dry acetylene gas, but the limiting pressure is 10 lb per square inch and a higher pressure than this is required for most applications.

PROPANE, BUTANE

It will be noted that in Table V the calorific value of propane is over one and a half times that of acetylene, yet the flame temperature is lower. This is readily explained by referring to Table III, where it will be seen that the flame velocity of propane is much lower than that of acetylene, and to Table IV, where the flame lengths and flame spreads are much greater than for any of the other three gases :

TABLE V—*Combustion Constants of Various Gases*

Gas	Net calorific value, B.Th.U. per cu ft	Oxygen ratio	Theoretical flame temperature, deg. Cent.
Hydrogen	274·5	0·5	2210
Methane	912·0	2·0	2066
Propane	2309–2474	5·0	2116
Butane	3010	6·5	2312
Acetylene	1433–1456	2·5	2632
Coal gas	500–530	1·1	2154

(Values from Haslem and Russell, *Fuels and Their Combustion*, published by the McGraw-Hill Book Company, Inc., 1926, and "Oxy-Gas Cutting," by Taylor and Bound, *Welding*, November, 1947.)

It should be noted that actual flame temperatures are higher than the theoretical—see Tables I and VII. A final clarification of this point is made in Table VI, which shows the rate of heat release of various oxy-gas mixtures. This indicates that the flame temperature of oxy-acetylene is the highest for any common oxy-gas combination.

TABLE VI—*Calorimetric Tests on Various Oxy/Gas Combinations*

Gas	Average vol. in cu ft per hour		Average heat release, cals. per minute
	Gas	Oxygen	
Acetylene	19·6	26·0	34,986
Propane	14·9	36·5	32,778
Propane plus 1·5 per cent ether	13·8	35·6	29,712
Propane	14·9	50·2	27,078
Propane, plus 1·5 per cent ether	14·5	44·7	25,788
Coal gas	62·5	56·4	28,686
Coal gas with 30·0 per cent Ferrolene*	49·2	53·0	27,510

* See page 6.

(Computed from results quoted in "Oxy-Gas Cutting," by Taylor and Bound, *Welding*, November, 1947.)
(Note that here the enriched coal gas contained 30 per cent Ferrolene, whereas it is usual to employ about 3 per cent for metal spraying.)

It is interesting to note that in the second test the oxygen ratio is 3·79, while in the fourth test it is 3·37, the latter ratio being accompanied by a lower rate of heat release. When one remembers that for the total combustion of propane a ratio of 5·0 is required, it would appear to be advantageous to supply this ratio of oxygen. However, in the opinion of the authors, the combustion of hydro-carbons is basically a two-stage reaction, consisting, in the first stage, of the oxidation of the carbon to carbon monoxide and the hydrogen to water vapour. The second stage continues the oxidation of the carbon monoxide to carbon dioxide, as illustrated in the case of acetylene :

First Stage.—

$$2C_2H_2+3O_2=4CO+2H_2O.$$

One volume of acetylene required 1·5 volumes of oxygen.

Second Stage.—

$$4CO+2O_2=4CO_2$$

(where the oxygen is taken from the subsidiary air stream).

In Table I it will be noted that between an oxygen ratio of 1·5 and 2·0 the flame temperature decreases and on page 6 it has been noted that a ratio of 1·7 gives the maximum flame temperature. It is considered that if perfect mixing of the gases were accomplished the maximum flame temperature would be attainable at an oxygen ratio of 1·5.

The statement that the combustion of hydro-carbons is basically a two-stage process may appear to be inaccurate in the light of the hydroxylation theory, which has been substantiated by practical experiment. However, this theory only explains the mechanism of the intermediate chemical reactions in the flame and the end result does not differ from that discussed above.

Considering the combustion of propane :

First Stage.—

$$2C_3H_8+7O_2=6CO+8H_2O.$$

One volume of propane requires 3·5 volumes of oxygen.

Second Stage.—

$$6CO+3O_2=6CO_2$$

(where the oxygen is again taken from the subsidiary air stream).

Therefore propane requires an oxygen ratio of 3·5 if perfect mixing were possible. In practice the ratio is about 4·0, which is proportionally only slightly higher in excess of oxygen than in the case of acetylene. This slight increase may be due to a greater difficulty in mixing propane with oxygen than when mixing acetylene with oxygen, the molecular structure of the latter being simple and open. It will be seen in Table VII that the highest flame temperature is attainable when the oxygen ratio lies between 3·5 and 4·5.

TABLE VII—*Properties of the Oxy-Propane Flame*

Oxygen/propane ratio	Flame condition	B.Th.U. liberated, per lb Mol.	Flame temperature, deg. Cent.
1·5 : 1·0	Neutral	92,000	1,150
2·0 : 1·0	Neutral	199,000	1,930
2·5 : 1·0	Oxidising	305,000	2,590
3·0 : 1·0	Oxidising	380,000	2,870
3·5 : 1·0	Oxidising	429,000	2,930
4·0 : 1·0	Oxidising	456,000	2,980
4·5 : 1·0	Oxidising	477,000	2,930
5·0 : 1·0	Oxidising	488,000	2,870

The values are based on the combustion of 44·06 lb of propane or 1 lb mol.
(Taken from *Oxygen Cutting* by Slottman and Roper, published by McGraw-Hill Book Company, Inc.

When spraying zinc with the Schori Model 50 pistol the quantity of propane used per hour is about 30 cubic feet and oxygen is consumed at the rate of 110 cubic feet per hour. This gives an oxygen ratio of 3·8 which corresponds to a flame temperature of nearly 3000 deg. Cent. Similarly, for spraying aluminium, the quantity of propane is 44 cubic feet per hour and oxygen is consumed at the rate of 178 cubic feet per hour, giving an oxygen ratio of 4·0.

It will be noted that right down to an oxygen ratio of 2·5 the flame is producing oxidising conditions and therefore propane is not used for welding. In the case of metal spraying it is usual practice to convey the powder in coal gas so as to prevent oxidation in the flame when propane is used as the fuel gas.

The combustion of propane is an endothermic reaction so less heat is released than would be calculated from the carbon and hydrogen contents. The calorific value (see Table II) is 2520 B.Th.U. per cubic foot, so in aluminium spraying, where 44 cubic feet per hour is used, the heat input is $44\times2520=1\cdot109$ therms per hour, which is about one-third as much again as in the case of acetylene.

The full combustion of propane is :

$$C_3H_8+5O_2=3CO_2+4H_2O,$$

so that 1 volume of propane produces 7 volumes of combustion products, or, in the case of aluminium, 44 cubic feet of propane produces 308 cubic feet of combustion products—almost twice the quantity produced from acetylene—which compensates for the lower flame temperature, and permits satisfactory metal sprayed coatings to be produced.

It has been shown experimentally that air may be substituted for oxygen for the spraying of zinc or other low melting point metals using acetylene as the fuel gas. This is not possible with propane for several reasons. First, the nitrogen, comprising four-fifths of the volume of air, has to be heated and this reduces the effective flame temperature, but equally important is the reduction in the range of limits of inflammability which lowers the stability of the flame. Referring to Table VIII, it will be seen that whereas the ignition range of acetylene is 2·5 to 80·0

TABLE VIII—*Ignition Limits of Gases in Oxygen and Air*

Gas	Volume, per cent, in Oxygen		Volume, per cent, in air	
	Lower ignition limit	Higher ignition limit	Lower ignition limit	Higher ignition limit
Methane	6·5	51·9	5·0–5·8	13·3–15·0
Propane	2·4	57·0	2·37	9·5
Butane	1·85	49·0	1·86	8·41
Acetylene	2·8	93·0	2·5	80·0
Hydrogen	4·65	93·9	4·0–6·2	7·14–74·2
Coal gas	7·4	69·7	7·0	21·0

(Values in oxygen taken from *Explosion and Combustion Processes in Gases*, by Jost, published by the McGraw-Hill Book Company, Inc., 1946. Values in air supplemented from *Fuels and Their Combustion*, by Haslem and Russell, published by the McGraw-Hill Book Company, Inc., 1926.)

(percentage volume of gas in air), that of propane is 2·37 to 9·5. Similar remarks apply to methane and butane.

Calor gas, which consists mainly of butane with up to 20 per cent propane and smaller percentages of butane, propylene and other hydro-carbons, may be used, and gives good results.

The chemical reactions in the combustion of butane are outlined as follows :—

First Stage.—

$$2C_4H_{10}+9O_2=8CO+10H_2O.$$

One volume of butane requires 4·5 volumes of oxygen.

Second Stage.—

$$8CO+4O_2=8CO_2.$$

Full Combustion of Butane.—

$$2C_4H_{10}+13O_2=8CO_2+10H_2O.$$

One volume of butane produces 9 volumes of combustion products.

There is no advantage to be gained in metal spraying by the use of propane enriched with ether, and it will be seen from Table VI that the rate of heat release is not increased.

Propane has one big advantage over most of the other common gases. It is supplied commercially in liquid form in large cylinders containing 100 lb (900 cubic feet). When coal gas is used for conveying the powder the propane consumption is reduced to 22 cubic feet per hour when spraying zinc, so one cylinder lasts for forty hours' spraying time. In the case of aluminium, 38 cubic feet of propane are required per hour and a cylinder will last for about twenty-three hours. If a propane manifold is used consisting of four cylinders, there is no loss of time in changing cylinders, and any number of powder spraying pistols can be supplied from one manifold.

Methane

Methane is not commercially available in this country except in very small quantities and the price quoted in Table X is only a nominal charge (rather on the high side), since the gas is a by-product from sewage disposal plant. It is readily available in the Americas, Canada, and recently in Italy from oil well drillings and is termed " natural gas." However, the term " natural gas " is applied to any gas obtained from oil well drillings and similar sources, and in a few cases ethane or propane may be the main constituent, as will be seen in Table IX :

In the powder spraying process, the application of aluminium requires 85 cubic feet of methane per hour and 137 cubic feet of oxygen, which gives an oxygen ratio of 1·6. Examination of the chemical equation for the combustion of methane indicates that this is approximately the ratio required.

First Stage.—

$$2CH_4+3O_2=2CO+4H_2O.$$

One volume of methane requires 1·5 volumes of oxygen.

Second Stage.—

$$2CO+O_2=2CO_2.$$

The calorific value of methane is 1011 B.Th.U. per cubic foot, so the heat input is $85\times1011=0{\cdot}86$ therms. Moreover, the final products of combustion are $3\times85=255$ cubic feet per hour, which compensates somewhat for the low flame temperature.

In Italy " natural gas " containing a very high proportion of methane is frequently used for powder metal spraying and the gas is piped to industrial centres from nearby oil wells.

Compressed Coal Gas

The composition of coal gas varies somewhat from one part of the country to another with calorific values from 400 to 500 B.Th.U. per cubic foot.

A typical analysis of London coal gas is as follows :—

	Per cent
Hydrogen	49·4
Methane	24·0
Carbon monoxide	16·4
Nitrogen	4·1
Carbon dioxide	3·3
Unsaturated hydro-carbons	2·1
Oxygen	0·6

The chemical equation for the combustion of coal gas is rather complex since so many reactions proceed simultaneously, but 1 volume of coal gas requires 1·05 volumes of oxygen producing 1·72 volumes of combustion products. For aluminium spraying 265 cubic feet of coal gas are required per hour, so the volume of combustion products is $265\times1{\cdot}72=456$ cubic feet per hour, which is the largest for any of the usual gases. The calorific value is approximately 500 B.Th.U. per cubic foot, so the heat input is $265\times500=1{\cdot}325$ therms, which is the highest for any of the gases dealt with in this paper. But, as will be seen from Table II, the cost per therm is the lowest. The flame length and the flame spread are very small (see Table IV), so the heat is concentrated in a small zone near the pistol nozzle and the temperature here is approximately 2000 deg. Cent. As one moves away from the hot zone the temperature falls off rapidly so that at 2½in from the nozzle the temperature is about 1260 deg. Cent. when spraying zinc. At 4in it is 945 deg. Cent., and at 6in it is 600 deg. Cent., due to the cooling effect of the peripheral cone of propelling air. But, even though the particles, on passing through the hot cone of the flame, do not reach as high a temperature as they do in the case of oxy-acetylene, the rate of cooling of the larger volume of combustion products in the case of coal gas is less than in the case of acetylene, so that the particles still strike the surface to be coated at, or near, the melting point. Flame temperature measurements confirm this, and in the case of zinc the particles strike the base at a temperature of between 380 deg. and 500 deg. Cent., while aluminium is deposited at a temperature between 620 deg. and 700 deg. Cent., thus explaining the fish-scale structure of sprayed metal coatings.

Not only is coal gas the cheapest fuel gas to use for the spraying of metals with a melting point under 1000 deg. Cent., but it is the most readily available gas in this country, and can be compressed from the mains supply to the requisite pressure.

As with propane, it is of no advantage to enrich coal gas with ether. It will be seen in Table VI that the rate of heat release of coal gas enriched with 30·0 per cent Ferrolene is no greater than that of normal coal gas.

Table X—*Comparison of Gas Costs for Spraying Zinc*

Gas combination	Consumption in cu ft/hr	Cost per 1000 cu ft, s. d.	Cost per hour in pence	No. of sq ft of surface sprayed per hour at 0·001in thickness	Cost per sq ft at 0·001in thickness, pence
Propane	22	74 0	19·6	634	0·092
Oxygen	77·5	30 0	28·0		
Conveying coal gas	150	6 0	10·8		
Propane	29	74 0	25·8	634	0·103
Oxygen	110	30 0	39·6		
Acetylene	36	147 6	63·7	634	0·123
Oxygen	40	30 0	14·4		
Methane	64	50 0	38·4	634	0·127
Oxygen	116	30 0	41·8		
Coal gas enriched with 3 per cent Ferrolene	110	18 6	24·4	634	0·107
Oxygen	120	30 0	43·2		
Coal gas	120	6 0	8·6	634	0·076
Oxygen	110	30 0	39·6		

(Based on a zinc powder throughout of 35 lb/hr.)

Table XI—*Comparison of Gas Costs for Spraying Aluminium*

Gas combination	Consumption in cu ft/hr	Cost per 1000 cu ft, s. d.	No. of sq ft of surface sprayed for hour at 0·001in thickness	Cost per sq ft at 0·001in thickness, pence	Powder throughout, lb/hr
Propane	38	74 0	415	0·244	7·5
Oxygen	158	30 0			
Conveying coal gas	150	6 0			
Propane	44	74 0	415	0·249	7·5
Oxygen	178	30 0			
Acetylene	56	147 6	415	0·291	7·5
Oxygen	60	30 0			
Methane	85	50 0	553	0·181	10·0
Oxygen	137	30 0			
Coal gas enriched with 3 per cent Ferrolene	265	18 6	830	0·168	15·0
Oxygen	230	30 0			
Coal gas	265	6 0	830	0·118	15·0
Oxygen	220	30 0			

Table IX—*Constitution of Some Natural Gases*

Natural gas	Methane, per cent	Ethane, per cent	Propane, per cent	B.Th.U. per cu ft (net), 60 deg. Fah.	Theoretical flame temperature, deg. Cent.
Follansbee, U.S.A.	—	21·8	77·0	2268	2120
McKean County, U.S.A.	32·3	67·0	—	1350	2080
Sandusky, U.S.A.	83·5	12·5	—	946	2065

(From *Fuels and Their Combustion*, by Haslem and Russell, published by the McGraw-Hill Book Company, Inc., 1926.)

Referring to the paper "Oxy-Gas Cutting," by Taylor and Bound (*Welding*, November, 1947), from which this table is taken, it will be found that the cutting rate is not increased by the use of enriched coal gas and that the cost is greater when enriched coal gas is employed. This also has been found to be the case in metal spraying. Experimental work has shown that coal gas is perfectly satisfactory without any enrichment, and, as will be seen in Tables X and XI the use of enriched coal gas involves approximately a 50 per cent increase in cost of gases per hour, compared with normal coal gas.

A final point, which cannot be dealt with adequately in this paper because information is as yet incomplete, is the adjustment necessary in the flame conditions due to the thermal conductivity of the metal being applied. Thus lead is sprayed under approximately the same conditions as zinc, since the lead particles do not heat up so rapidly as zinc, and they therefore require to be projected through the same length of heating zone. The thermal properties of some of the common metals are listed in Table XII, and

TABLE XII—*Thermal Properties of Some of the Common Metals*

Metal	Thermal conductivity (silver = 1·0)	Specific heat (water = 1·0)	Melting point, deg. Cent.
Copper	0·93	0·094	1083
Aluminium	0·506	0·209	659
Zinc	0·270	0·0935	419
Tin...	0·156	0·056	232
Iron	0·148	0·134	1530
Lead	0·085	0·0315	327

(From British Oxygen Company, Ltd., Handbook.)

another interesting point is that copper is sprayed under the same flame conditions as aluminium due to the very high heat conductivity of the former metal. The flame temperature when copper or aluminium is being sprayed is still over 1200 deg. Cent. at a distance of 6in from the pistol nozzle, at 8in it is approximately 1000 deg. Cent., at 10in., 760 deg. to 780 deg. Cent., and at 12in it is just over 600 deg. Cent. Aluminium is sprayed with the nozzle 11in from the base, and copper at approximately 8in from the base.

Economics

The order of economy for zinc spraying is coal gas, propane, enriched coal gas, acetylene and methane, acetylene being 40 per cent more expensive than coal gas. In the case of aluminium the order is coal gas, enriched coal gas, methane, propane and acetylene, the last being 15 per cent more expensive than coal gas. These costs are based on prevailing prices in Great Britain and different figures may obtain abroad.

In the case of coal gas and enriched coal gas, owing to the large volume of products of combustion, it is particularly noticeable that a very high throughput of aluminium powder can be achieved, as compared with other gases, but it is emphasised that the figures for throughput incorporated in these tables are those which provide the requisite solidity and adhesion values in accordance with accepted standards.

For metals with a melting point greater than 1000 deg. Cent., it is necessary to use propane or acetylene, and the latter gas gives the most satisfactory results. In the case of hard-surfacing nickel-based alloys which are susceptible to rapid oxidation, acetylene must be employed to ensure that reducing conditions are obtained at a very high flame temperature.

All results quoted without reference were obtained by the Research Department, of Schori Metallising Process, Ltd., London, England.

The Royal Show at Blackpool

No. I

NEXT week, from Tuesday, July 7th, to Friday, July 10th, the Royal Agricultural Society's annual show is to be held at Blackpool. The president of the Society this year is the Earl of Derby, and Lieut.-Colonel Guy Blewitt is the honorary director of the show. The show will be the 105th in the series organised by the Royal Agricultural Society, for although the first show was held in 1839, the annual sequence has been broken, first in 1866, owing to a rinderpest epidemic, and in more recent times by the two world wars. This is the first occasion on which the Royal Show has been staged at Blackpool, although it will be the ninth show in the series to be held in Lancashire. The first Royal Show in the county was at Liverpool in 1841, when, amongst the machinery exhibits, a portable steam thresher attracted considerable attention. It was a product of Ransomes, Sims and Jefferies, Ltd., but although it was acclaimed as an innovation, it received no more than a "commendation" from the judges in an implement competition. In addition to three Royal Shows in Liverpool, there have been four in Manchester and one in Preston. All of them have drawn large attendances. The last time the show was held in Lancashire was at Manchester in 1930. In the machinery section, there were then 443 stands, and the exhibits included a British made combine-harvester, or harvester-thresher, as we then described it.

Next week's show at Blackpool is to be held on the site of the former Stanley Park Airport. The showground extends over an area of 136 acres, and there are, in addition, 80 acres of car parks. Work on the preparation of the site and the construction of the shedding and pavilions has been going on since last September. Some idea of the magnitude of the preparatory work involved can be gained from statistics issued recently by the Royal Agricultural Society. It has been necessary, for example, to level 59 acres of the ground, and to remove 5000 tons of rubble and 1700 yards of hedges, while for seeding and filling up hollows 17,000 tons of soil have been shifted. The length of shedding required for the show, apart from the stands erected by exhibitors, is no less than 4 miles; there are 9 miles of water and service mains, 8 miles of electricity cable, and 30,000 railway sleepers have been put down for roadways. Last year, the epidemic of foot and mouth disease which was affecting many parts of the country compelled the cancellation of the exhibits of cattle, sheep and pigs at the Royal Show, which was held at Newton Abbot. This year, happily, the country is virtually free of the disease, and the entries in all classes of livestock are well up to the average.

Our concern, of course, is, as usual, with the machinery section of the Royal Show. The commercial stands for the exhibition of agricultural and horticultural machinery and equipment this year number 620, compared with 570 last year, and will occupy an area of 1,200,000 square feet. On these stands, there will be displayed examples of the many machines and implements which are contributing so much to the success of this country's mechanised agriculture, and which, in addition, form an increasingly valuable part of our export trade. Much of the machinery which will be seen at Blackpool has already been described in these columns, but on many stands there will be shown new developments and products. In that which follows we begin an illustrated account of a representative selection of the machinery and other equipment.

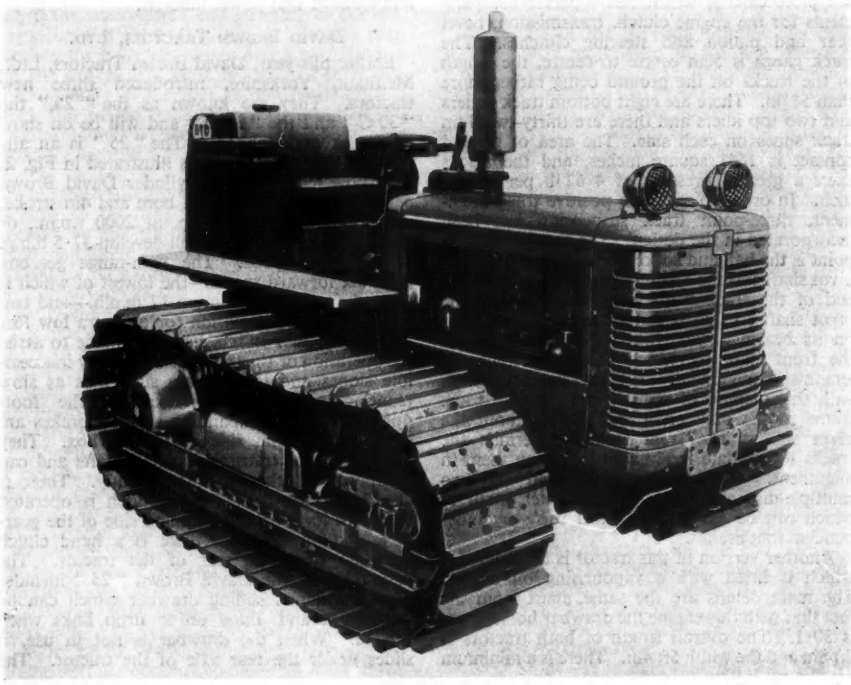


Fig. 1—Diesel Crawler Tractor—International Harvester

International Harvester Company of Great Britain, Ltd.

A new diesel crawler tractor, which the International Harvester Company of Great Britain, Ltd., 259, City Road, London, E.C.1, is about to put into production at its Doncaster works, will be one of that firm's principal exhibits. A view of the tractor, which is designated "BTD-6," is reproduced in Fig. 1. The engine installed in this tractor was introduced by the company towards the end of last year. It has four cylinders, 4in bore by 5½in stroke, and at an engine speed of 1450 r.p.m. the tractor has a drawbar horsepower of 31·3. Transmission is through a single-plate 12in clutch, and there is provision for five forward speeds, between 1·5

Fig. 2—The " 25 " Light Tractor—David Brown

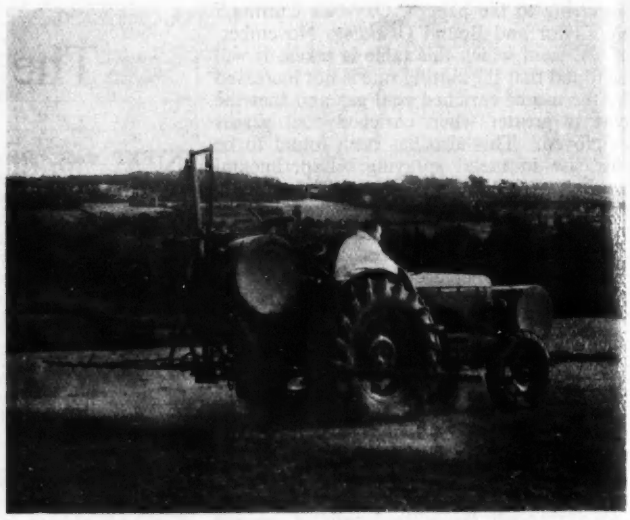


Fig 3—" 30C " Tractor with Watson Sprayer—David Brown

m.p.h. and 5·4 m.p.h., and one reverse speed of 1·7 m.p.h.

The " back-bone " of the new tractor is a one-piece casting which has separate compartments for the engine clutch, transmission, bevel gear and pinion and steering clutches. The track gauge is 50in centre to centre, the length of the tracks on the ground being rather more than 58½in. There are eight bottom track rollers and two top idlers and there are thirty-two 14in track shoes on each side. The area of ground contact is 1641 square inches, and the tracks exert a ground pressure of 4·62 lb per square inch. In order to maintain positive track alignment, three-point track suspension has been incorporated in the design. The first suspension point is the ball and socket joint at the end of the pivot shaft and the second point fastens the inner end of the track frame diagonal brace to the pivot shaft so that it cannot move up or down on its bearing. The third suspension point is the front stabiliser which keeps the tracks in lengthwise alignment. The makers claim that, with this method of mounting, the entire track frame moves only on a true radius about the pivot shaft. The front stabiliser permits the tracks to oscillate freely whilst keeping them in alignment. The tractor is steered by two multiple-disc clutches, 10⅞in diameter, both of which can be assisted for short turns by independent foot brakes.

Another version of this tractor is the " BT–6," which is fitted with a vapourising oil engine. The main details are the same, apart from the fact that with this engine the drawbar horsepower is 30·1. The overall length of both tractors is 8ft 8in and the width 5ft 4in. There is a minimum ground clearance of 8½in, the drawbar height is 12½in, and the turning radius 6ft 2in. Special attachments to each tractor include a belt pulley and front or rear power take-off.

David Brown Tractors, Ltd.

Earlier this year, David Brown Tractors, Ltd., Meltham, Yorkshire, introduced three new tractors. They are known as the " 25," the " 30 C " and the " 30 D," and will be on show next week at Blackpool. The " 25 " is an all-purpose light tractor and is illustrated in Fig. 2. It is powered by a four-cylinder David Brown petrol-paraffin engine, 3½in bore and 4in stroke, which develops 31·7 b.h.p. at 2000 r.p.m., or by a petrol engine which will develop 37·5 b.h.p. at the same speed. The twin-range gearbox gives six forward speeds—the lowest of which is 1 m.p.h. and the maximum 17 m.p.h.—and two reverse speeds. Provision for an extra low forward speed of 1 m.p.h. has been made to assist the operation of the tractor on normally inaccessible slopes and to facilitate such jobs as slow planting and precision hoeing. The foot-operated internal expanding steering brakes are on the right-hand side of the gearbox. They operate on the transmission half-shafts and can be applied together or independently. There is also a parking brake. The clutch is operated by a foot lever on the left-hand side of the gearbox, and, in addition, there is a hand clutch operated from the rear of the tractor. The equipment of the David Brown " 25 " includes a self-contained sliding drawbar which can be pulled out and fitted on to drop links when needed. When the drawbar is not in use, it slides under the rear axle of the tractor. The weight of the tractor is about 30 cwt. A two-speed power take-off and a two-speed belt pulley can be added to the tractor's standard equipment.

The other two new tractors which will be exhibited are the " 30 C " and the " 30 D," the latter of which has a diesel engine, 3⅝in bore and 4in stroke, developing 34 b.h.p. at 1800 r.p.m. This tractor is equipped with a two-speed power take-off and a two-speed pulley, and its power lift is operated by the David Brown Mark II gear pump. In the power lift arrangement there is a " hold " position which permits the operator to lock the linkage in the raised position at any height. Another item of equipment on the " 30 D " tractor is an adjustable drawbar which, for convenient handling, is split into two parts connected by hitch pins. A draw plate is fixed permanently to the centre of the tractor's rear axle for the speedy attachment of trailed implements.

In Fig. 3 we illustrate the " 30 C " tractor, which in most respects is similar to the " 30 D." The principal difference is that the power unit is either a petrol-paraffin engine giving 37·6 b.h.p. at 2300 r.p.m. or a petrol engine developing 41 b.h.p. at 2300 r.p.m. Our illustration shows a Watson crop sprayer mounted on the tractor. This is a recent addition to the implements now associated with David Brown tractors, a selection of which will be displayed on the stand. The sprayer, which is manufactured by L. H. Watson, Ltd., Orpington, Kent, includes two tanks with a combined capacity of 100 gallons. It consists of a fabricated angle iron frame which is mounted on the tractor linkage and which carries the main tank of 60 gallons capacity, the pump and the spray booms. The auxiliary 40-gallon tank

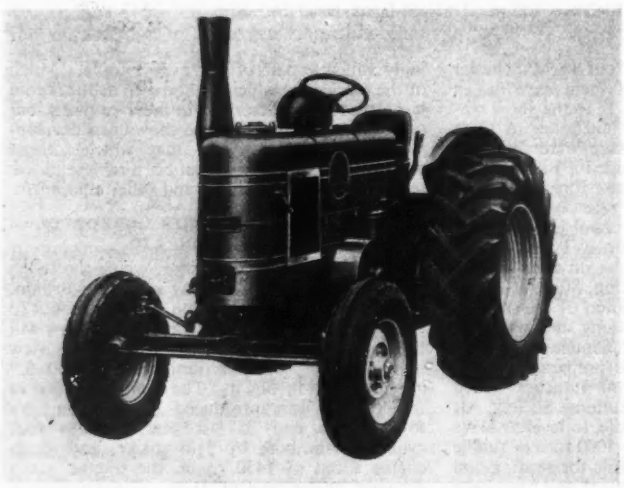


Fig. 4—40 b.h.p. Diesel Tractor—Marshall

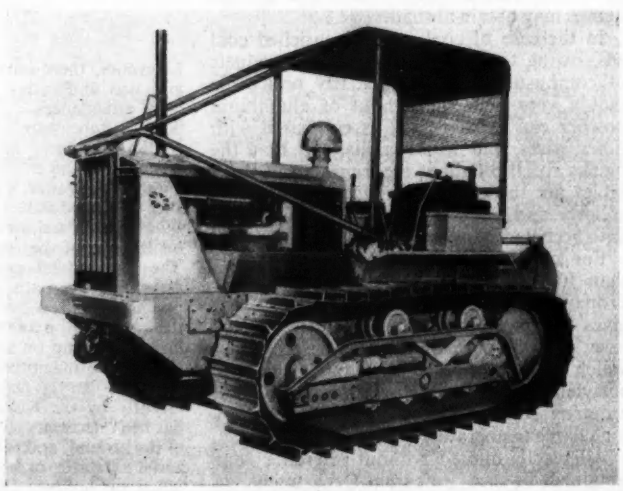


Fig. 5—Crawler Tractor with Logging Winch—Fowler

is mounted at the front end of the tractor. An even mixture of the spray liquid is maintained by drawing it from the bottom of the main tank and delivering it through a swirler rose to the auxiliary tank. From there the liquid passes to the pumping unit. The geared spray pump, which is driven from the power take-off shaft of the tractor has an output of 1450 gallons an hour at 750 r.p.m., the spray pressure being preset at 25 lb to 30 lb per square inch. The spray boom consists of two spring-loaded, laterally extending arms, giving a total ground cover of 24ft. Nozzle tappings are provided at intervals of 1ft along the booms.

MARSHALL, SONS AND CO., LTD., AND JOHN FOWLER AND CO. (LEEDS), LTD.

The tractors which will be seen on the stand occupied by the Marshall Organisation include the "Field-Marshall 3 A," which is a recent addition to the products of Marshall, Sons and Co., Ltd., Gainsborough. A photograph of it is reproduced in Fig. 4. The engine for this tractor is a Marshall horizontal single-cylinder, two-stroke diesel, 6½in bore and 9in stroke, giving 40 b.h.p. at a governed speed of 750 r.p.m. It incorporates C.A.V. fuel injection equipment, and there is foot and hand control of the spring-loaded cone clutch. The gearbox provides for six forward speeds between 2·6 and 9·1 m.p.h. and for two reverse speeds of 2 and 4·3 m.p.h. The remainder of the new tractor's equipment follows closely that of the "Field-Marshall" series. The overall length of the tractor is 10ft 2in, its width 6ft 4½in, and it has a ground clearance of 1ft 3in. A Marshall single-cylinder diesel engine of the same specification as that to which we have just referred is installed in the Mk. VFA crawler tractor, which will be exhibited next week, and which is a new production of John Fowler and Co. (Leeds), Ltd. This tractor is fitted with track plates 14in wide, the length of ground contact of each track being 60½in, and the gauge from centre to centre of tracks being 56in. The total area of ground contact is 1687 square inches and the ground pressure 6 lb per square inch.

In our issue of October 31, 1952, we described the Fowler "Challenger 4" heavy-duty crawler tractor which will be shown by the Marshall Organisation at the "Royal." It is powered by a Meadows engine which develops 150 b.h.p. at 1500 r.p.m. The maximum drawbar pull of this tractor is about 28,500 lb. Another tractor in this series is the "Challenger 3," which is illustrated in Fig. 5. This tractor has a Leyland six-cylinder diesel engine which develops 95 b.h.p. at 1550 r.p.m. The standard track width is 20in, and the weight of the tractor is 10½ tons. The "Challenger 3" to be shown at Blackpool is fitted with equipment for timber extraction. At the rear of the tractor there is fitted a direct-geared, single-speed, reversible logging winch which is operated by the power take-off. It includes a 13in cable drum, the line pull at 76ft a minute being 38,500 lb. To shield the operator and the controls, there is a tree canopy, the tubular steel framework of which is bolted to mountings on the tractor body. The top of this canopy protects the driver from any falling timber, and behind him there is a wire mesh screen which, while giving adequate protection, permits an unobscured view of the work at the rear and also free control of the winch. For the protection of the track rollers soil guards are bolted to the underneath of the track frame on each side of the bottom rollers, their purpose being to prevent ingress of dirt and stones between the track and the frames when the machine is slewing. The top rollers and support brackets are protected from logs and brushwood by steel fender rails which are bolted to the front and rear of the track frames. In addition, twin-rail steel guards, which are welded to the hull, extend from the front to the back of the tractor. If the tractor should be used for pushing purposes, such as in heavy undergrowth, the front bumper bar takes the strain and prevents damage to the hull and radiator block. The equipment is completed by a towing hook which is rigidly bolted to the front hull. The height of the tractor arranged with this timber extraction equipment is 9ft 5½in, and its length, including the winch and bumper bar, is 15ft 6in.

(*To be continued*)

Harrow and Wealdstone Railway Accident Report

On October 8th last year there occurred the disastrous double collision on the London Midland Region railway lines at Harrow and Wealdstone station, as a result of which 112 lives were lost. The report on this accident, prepared by Lieut.-Colonel G. R S. Wilson, Chief Inspecting Officer of Railways, was issued yesterday, and in what follows we print some extracts from it.

THE two trains concerned in the primary collision were the 7.31 a.m. up local passenger train from Tring to Euston, comprising nine non-corridor bogie coaches hauled by a 2–6–4 type tank engine, and the 8.15 p.m. up express passenger train from Perth to Euston, which consisted of eleven bogie vehicles, including four sleeping cars and three vans, hauled by a tender engine of 4–6–2 type. The third train, which ran into the wreckage of the first collision was the 8.0 a.m. down express from Euston to Liverpool and Manchester, consisting of fifteen bogie vehicles, including four vans at the rear; this train was double-headed, with a 4–6–0 type engine in front, and a 4–6–2 type engine attached to the coaches. The local train had crossed from the up slow to the up fast line at the country end of the station, and had stopped, as booked, at the up fast (No. 4) platform. It had been standing there for about one and a half minutes and the brakes had been released when it was struck heavily at the rear by the Perth express which had passed the colour-light distant signal at caution and two semaphore signals at danger in patchy fog and was travelling at 50–60 m.p.h. on the up fast line; the express had burst through the trailing points of the crossover from up slow to up fast, as they were still locked reversed by the up fast starting signal ahead which had been cleared for the local train to proceed on its journey. The resulting wreckage was spread across the adjacent down fast line on which the Liverpool express was approaching at not much less than 60 m.p.h., and the leading engine of this train struck the derailed engine of the Perth train a second or two after the first collision. Both of the Liverpool train engines were diverted to the left across one of the platforms and were overturned foul of the up electric line close to the No. 2 signalbox which controls the electric lines only. The current was removed from the conductor rails of the up line by the resulting short circuit, and from the down line by the prompt action of the signalman; an up electric train from Watford was stopped well clear by the loss of current, and by the automatic reversal of the up line home signal to danger. The damage to the three express engines and the destruction of rolling stock by the two collisions at high speed were altogether exceptional. Three passenger coaches of the local train, three of the Perth train and seven of the Liverpool train, as well as two bogie vans and a kitchen car, were demolished or very heavily damaged; thirteen of these sixteen vehicles were compressed into a compact heap of wreckage about 45 yards long, 18 yards wide and 30ft high, completely burying the engine of the Perth train as it lay foul of the down fast line. One end of the wreckage was jammed under the station footbridge, a steel girder of which was torn away.

It was inevitable that the casualty list was very great, particularly as the local train was crowded, and indeed the death roll has only once been exceeded in an accident on the British railways. I much regret to record that 112 persons altogether lost their lives; ninety-eight passengers and four railway servants on duty were killed outright, including the driver and fireman of the Perth express and the driver of the leading engine of the Liverpool express, and ten passengers died later in hospital from their injuries. Of the 108 fatalities to passengers, there was evidence that sixty-four occurred in the local train, twenty-three in the Perth train, and seven in the Liverpool train; the remaining fourteen were not located, but it is probable that some passengers who were waiting on the island platform between the down fast and up electric lines were caught by the derailed engines of the Liverpool train.

CONCLUSIONS

I am entirely satisfied that the first collision resulted when Driver R. S. Jones did not reduce the speed of the Perth train in obedience to the Harrow No. 1 up fast distant signal at caution, and subsequently passed the outer and inner homes at danger. I am also satisfied that no responsibility should rest with Signalman Armitage, and once the first collision had occurred neither he nor the enginemen had any opportunity to prevent the down Liverpool express from running into the wreckage at speed.

REMARKS AND RECOMMENDATIONS

The results of the collision between the two up trains were aggravated in the first instance by the fact that the local train was more crowded than usual owing to the temporary cancellation of the next local service to Euston. It was still more unfortunate that the down Liverpool express was approaching so closely that no member of the staff had any opportunity to stop it or check its speed before it struck the wreckage of the first collision, resulting in a final casualty roll which has only once been exceeded in a railway accident in this country.

It is impossible to say to what extent the casualties among the passengers of the Perth and local trains were increased by this second collision. So far as could be ascertained, sixty-four passengers of the total of about 250 in the last three coaches of the local train lost their lives, or about 25 per cent, but the twenty-three passengers who were known to have been killed in the Perth train represented a much higher proportion of the number in its first three passenger coaches. It seems probable that a good many of the local train passengers were thrown clear on to the platform away from the down fast line as the wooden body sides were burst open and shattered by the first impact, while some of the Perth train passengers who had survived it were killed a few seconds later when the destruction of the sheet steel panelled coaches was completed by the coaches of the Liverpool train which overrode them.

Rolling Stock.—The eight fatalities which were known to have occurred in the Liverpool train itself are a surprisingly small number considering that the leading seven passenger coaches were involved in the wreck. This may be attributed to some extent to the workings of chance and it appears that the diversion of the two engines and the leading three coaches to the left may have lessened the damage to the rest of the train. It is, however, notable that the fourth and sixth coaches which were built in 1951 and 1952 to the new British Railways standard design, with all-steel welded bodies which were welded to the underframes, both kept their form as integral structures without very severe disturbance of the internal partitions and fittings. The fifth coach, which was built in 1950, also had an all-steel body, but it was of earlier design and was mounted on a standard London Midland Region underframe in the ordinary way; it was probably one of the first to strike the main body of the wreckage under the footbridge and its underframe and body were destroyed.

An exceptional disaster such as this, in which enormous destructive forces were applied to a large number of vehicles from different directions, can give no firm grounds for conclusions on the merits of different types of carriage construction from the safety point of view. I think, however,

it is fair to say that the comparatively modern composite coach body, with sheet steel panels and roof and hard wood framing, is not in itself a great deal stronger in structural resistance to collision forces than the older all-timber construction, though it is probable that casualties from splinters are lessened. The heavy steel underframes which have been adopted for all main line stock in recent years can sometimes give considerable protection against the crushing of the vehicle as a whole, but if overriding takes place their resistance is not brought into full play, and in these circumstances a heavy underframe may even add to the destruction by the well-known telescoping effect. The all-steel body shell mounted on a normal underframe is a step in advance and has proved its value more than once in collisions where conditions were less severe, but no carriage body for service in this country can be built, even in steel, to withstand the very violent shocks which must have been received by the fifth coach of the Liverpool train.

With a strict necessity to save weight, it seems that the right line of approach is to design and build our railway carriages so that the strength of the body and underframe can be developed as a more or less homogeneous structure, each reinforcing the other, so as to enable the best use to be made of all the material to resist shock loads. The new British Railways standard all-steel coaches, of which the underframes alone are nearly twice as strong as any of the Regional designs, go a long way in this direction. Corridor coaches are also provided with rigidly holding central Buckeye couplings which were standardised by the former London and North-Eastern and Southern Companies for their main line stock and have proved their value on past occasions in reducing the risks of telescoping ; by careful design the weight of a corridor passenger coach has been kept down to 34 tons or less, which is about the maximum which can be accepted in this country where a definite limit is set to haulage power by the restricted loading gauge. I have no doubt that as manufacturing technique is developed, further advances will be made in strength without increase of weight, but design must also take account of ease of repair, and cost cannot be disregarded.

No practicable form of carriage construction can be relied on to prevent casualties when heavy trains collide at high speed, as the energy which has to be dissipated in a short time and space is so very great, and this has been shown by recent cases abroad where it is possible to operate steel coaches of very heavy construction. It does seem possible, however, that the wreckage at Harrow might have been less compact, and the killed and injured fewer, if a greater proportion of the rolling stock had been of the latest all-steel type and rigidly coupled.

There are now 1100 coaches of the new standard design in service on British Railways of a total of about 37,000 steam-hauled passenger vehicles, although shortage of steel prevented any new construction under the 1952 carriage renewal programme. The steel position is now much better and it is anticipated that the standard coaches will be coming into traffic at the rate of about 1200 a year from now until 1956, when the arrears of replacement should have been overtaken, and at about 650 a year thereafter. There will thus be a progressive general improvement in the strength of passenger rolling stock, but railway coaches are necessarily built for long life, and some years must elapse before the standard coaches predominate, even in long-distance trains. Similarly, there will be a long transition period before Buckeye couplings are in general use with corridor stock on the routes of the former London Midland and Scottish and Great Western Railways on which ordinary screw couplings were standardised.

Marshalling.—The two bogie vans at the front of the Perth express undoubtedly saved serious damage to the passenger coach marshalled sixth and to the following sleeping car. The value of such protection has been recognised and instructions were issued to all Regions in 1948 that a brake van or vehicle with a brake compartment at the leading or trailing end should be marshalled at the front or rear of passenger trains wherever practicable. The local train in this case was marshalled with the rear brake compartment at the trailing end of the seventh coach, but as this brake compartment was swept away in the wreckage I would not suggest that any casualties would have been saved if it had been at the extreme rear of the train.

It will be noted that the new standard coaches in the Liverpool train were marshalled fourth, sixth and eleventh. As time goes on, more and more standard coaches will be mixed with screw-coupled coaches in train formations. They cannot always be marshalled together, but I think that this should be done wherever it is practicable so that advantage can be taken of their Buckeye couplings.

Operating and Rules and Regulations.—The late running of the three trains contributed to the accident only in the sense that it brought them into proximity quite fortuitously at the time and place, and the short interval between the two up trains required one of them to be held at signals so as to give precedence to the other in the ordinary course of junction working. There are good reasons for giving precedence to the London residential trains in the morning when main line expresses are running late, as is unavoidable in foggy weather, and in order to keep them as nearly as possible to time and avoid the dislocation of other movements it is necessary to hold them to their planned routes on the fast and slow lines at the expense of checks or stops to the long-distance expresses, either at the cross-over junctions or in the ordinary course of block working. It should be clearly understood, however, that these are matters which affect the efficiency of traffic operation rather than safety. It is fundamental that the safety of railway traffic must depend at all times on the obedience to signals.

By permitting the acceptance of a train when a junction in its path is occupied only where there is an outer as well as an inner home signal, I consider that the Absolute Block Regulations go as far as is reasonably practicable to provide for ordinary misjudgment by drivers in clear weather. The circumstances at Harrow were, in fact, no different from those at the many converging junctions in the country which are equipped with outer home signals, whether they are geographical junctions or junctions between parallel lines on the same formation. As has been stated, such additional homes have been provided specially to give a margin for over-running so that trains may be accepted freely, but no such margin can allow for disregard of all the signals. Detonator placers worked from the signalbox can sometimes be a very valuable safeguard in such an emergency, and they were used in this case ; the distance, however, was much too short for them to have any effect.

It is probable that patchy fog in the section contributed to the first collision, although the visibility at Harrow No. 1 box was considerably more than the minimum which is laid down for normal working. Signalmen, however, must of necessity be guided by arbitrary rules which cannot provide for every contingency, and the rules and regulations for train working in fog have proved adequate in practice with the aid of the professional skill and care which is displayed by engine drivers throughout the country on the vast majority of occasions. The way to guard against the exceptional case of human failure of the kind which occurred at Harrow does not lie in making the regulations more restrictive, with consequent adverse effect on traffic movement, but in reinforcing the vigilance of drivers by apparatus which provides a positive link between the wayside signals and the footplate. This is known as automatic train control. The type known as " warning control " which gives an audible warning in the cab and a brake application when a distant signal is passed at caution has been installed on the lines of the former Great Western Railway for many years, and is in use on the Tilbury line of the former London, Midland and Scottish Railway ; as will be seen later, there are now firm prospects of its extension to other routes on a comprehensive scale.

Automatic Train Control.—In the forty-one years 1912–1952, formal inquiries were held into 640 train accidents in which 1416 persons were killed. Of these accidents, sixty-six, or rather more than 10 per cent, might have been prevented or mitigated by automatic train control of warning type, but it will be noted that the fatalities which might have been saved were 28 per cent of the forty-one-year total, or 399 lives in all, including 112 at Harrow.

The much greater proportion of the fatalities is not fortuitous, as warning control affords valuable protection against failure to act on the distant signal at caution, which may well lead to a collision or turnout derailment at high speed with very serious consequences, experience having shown that if speed is not reduced when the distant is passed at caution there is a grave risk that subsequent stop signals may also be disregarded. The high value of warning control under main line conditions is also emphasised by the fact that if more elaborate and very much more costly forms of apparatus, such as continuous cab signals, speed control or train stops had been in use as well as warning control, the proportion of fatalities which might have been saved would only have risen from 28 to 36 per cent.

That, in short, is the case for warning control. The view is generally held that warning control alone is best suited to the main lines of this country, although train stop control is essential and is provided under the special conditions of the London Transport and other similar railways. This view found its expression in the following reference to automatic train control which was included in the Requirements of the Minister of Transport when they were revised in 1950 :

" Equipment of train-stop type, with suitable proving controls, to be provided on urban electric railways in tube or tunnel, and on their extensions in the open. An approved form of equipment of warning type for distant and multi-aspect signals is desirable on important main lines."

For many years before that the Government, acting on recommendations of the Inspecting Officers of Railways, had urged that the fullest consideration should be given by the railways to the extension of automatic train control, and special committees were appointed in 1922 and 1927 to review the question, the latter under the chairmanship of Colonel Sir John Pringle, who was then Chief Inspecting Officer. The " Pringle Committee " reported in 1930 and recommended increasing safety by direct (automatic) and indirect methods, with a general preference for the former, and emphasis on the contact system which the Great Western Railway had begun to develop in 1905, and which was already in fairly extensive use. The Committee took note, however, of the non-contact magnetic " Hudd " system and suggested that it should be tried under working conditions. With regard to indirect methods, the Committee included recommendations for increasing the illuminative and penetrative power of signal lights and the extension of certain types of block control to prevent errors by signalmen.

The report was referred to the railway companies, but except for the Great Western they did not consider that automatic train control, which would require apparatus on the train, was justified on account of the great expense and the small number of accidents which it would prevent, and they proposed that indirect methods should be fully developed. They agreed, however, that further exploration of automatic train control generally was desirable, pointing out that the Great Western system was already twenty years old, and that trials with more modern apparatus were in progress.

In 1931 and 1932 trials were carried out with the Hudd system by the Southern and London, Midland and Scottish Railways, and in 1937 the latter company proceeded to install it on its London Tilbury and Southend section and equipped 150 locomotives for the purpose. This installation was finally approved by the Minister in 1947, on the recommendation of the Chief Inspecting Officer of Railways. The system has since worked satisfactorily in all weathers. In the meantime the Great Western Railway had been steadily extending the contact system, and on the outbreak of war in 1939 the great majority of its main line mileage and practically all its locomotives had been equipped. The London and North-Eastern Railway had kept in touch with the London, Midland and Scottish trials and in 1938, after the serious collision at Castlecary, was beginning to install the Hudd

system between Edinburgh and Glasgow, but the work was stopped by the war.

The Southern Railway, on the other hand, while satisfied with the results which had been gained, decided not to proceed further with the matter at that time, preferring to spend money on colour-light signalling with continuous track circuiting, the heavy cost of which was justified by the intense electric passenger services ; it was maintained with some justification that the arresting effect of a succession of colour-light signals made automatic train control less necessary, and that track circuiting was a strong safeguard against signalmen's mistakes which could not be prevented by automatic train control.

The subject was again brought into prominence by the serious accident at Bourne End in 1945, where a colour-light distant signal was disregarded or misinterpreted in daylight and clear weather. The report of Lieut.-Colonel Sir Alan Mount, then Chief Inspecting Officer, included a strong recommendation for the application of warning control to main lines, and the railway companies were asked to deal specially with this and other items in submitting to the Minister their proposals on the recommendations of the report. They replied in December, 1947, through the secretary of the Railway Clearing House, and the letter contained the following paragraph :

" It should be pointed out that, apart from the question of finance, the general installation of automatic train control, even of the warning type, on main lines where this does not already exist, would occupy a considerable time and employ a large number of skilled men. The supply of such staff is strictly limited, and its employment on this installation would therefore necessarily delay the execution of other work such as the modernisation of signalling, the extension of track circuiting and other similar works."

That was the general position when the British Transport Commission and the Railway Executive assumed control on January 1, 1948. In the meantime, another serious accident had occurred at Goswick where a semaphore distant was ignored at caution, and Sir Alan Mount concluded his annual report for 1947 with a reference to automatic train control in the following terms :—

" There are substantial grounds for the extension of such equipment, and it deserves high priority in relation to other operating and signalling improvements, particularly as the majority of railway mileage is likely to remain signalled under the semaphore system for a long time."

It will have been noted that there were two systems of warning control in established day-to-day service on the vesting date. By far the most extensive was the Great Western contact system which was in use on 1356 miles of route. It works by means of a fixed insulated ramp at the distant signal by which a plunger on the locomotive is raised. When the distant is at caution the ramp is " dead " and the raising of the plunger sounds a siren in the cab and gives an application of the brake which can be cancelled by the driver. With the distant at clear, a small electric current is applied to the ramp, which prevents the siren and brake from acting and causes a bell to sound in the cab ; the current is returned through the running rails.

The Hudd system, as modified by the London, Midland and Scottish Railway, was in use on 37 route-miles between Fenchurch Street, Tilbury and Southend. It is a magnetic system which does not depend on physical contact. A permanent magnet, followed at a short distance by an electromagnet, is located between the rails at the distant signal. With the distant at caution, the electromagnet is not energised, and the permanent magnet reverses inductively the armature of a receiver under the locomotive ; reversal of the armature opens a small valve to reduce the vacuum in a pilot reservoir, which in turn sounds a siren and gives a cancellable brake application, as in the Great Western system.

With the distant at clear the electromagnet is energised to an opposite polarity. The siren begins to sound at the permanent magnet, but it is quickly suppressed as the receiver armature is restored to normal by the electromagnet before the brake can take effect. The equipment operates pneumatically, and there are no electric circuits on the engine. The audible signals on the footplate, namely, a long sound of the siren for caution and a short sound of the same note for clear, are not nearly so distinctive as the siren and bell of the Great Western system.

The position in the Western Region and on the Tilbury and Southend line remains unchanged to-day, with a total of 1393 route-miles equipped with warning control.

After some small-scale comparative trials early in 1948, and discussions with the Inspecting Officers, the Railway Executive put forward tentative proposals for a programme to extend warning control on main line routes based on one or another of the two systems. They considered that it should be initiated as soon as circumstances would allow, and envisaged an expenditure of some £6,000,000 staged over six years, but they indicated that the technical problem was not fully solved and that further research was necessary. They also recommended a programme of the same order for the extension of track circuiting and block controls to prevent errors by signalmen. The desirability of all these measures was accepted in principle by the Commission, as was indicated by their published report for 1948.

The Railway Executive then gave consideration to the merits of the two systems. At first they were inclined to favour the Great Western contact system which had operated successfully for many years under steam traction, but subsequent tests with it showed that there was a serious risk of false indications by stray earth currents on lines electrified either with conductor rails or overhead collection ; it was also found that there was insufficient clearance between the ramps and the motor cases of multiple-unit electric trains. These alone were felt to be important objections to the adoption of the system as a long-term future standard for all forms of traction, and after reviewing the question further the Executive also considered that it would be unwise to standardise a system in which heavy mechanical parts were brought into contact with each other at a time when more modern methods of " pick-up " were available ; other objections of less moment were also mentioned, including the interference of the ramps with snow ploughs under severe conditions in the North and difficulties of adapting the equipment to fit the variety of cab layouts in other Regions. Although the Hudd system embodied the non-contact principle which was desired, it was not considered wholly satisfactory, mainly because there was not sufficient differentiation between the caution and clear indications.

After a series of meetings with the Inspecting Officers, the Railway Executive proposed in August, 1948, that apparatus combining the best features of the two systems should be developed. After examining a sketch design, the Inspecting Officers informed the Executive that they saw no inherent objection to it, subject to unquestioned proof of its reliability and efficiency in large-scale trials for which they suggested at least twelve months would be required. The Inspecting Officers, however, expressed the strong opinion that the Great Western contact system which was already well proven should not be discarded without thorough investigation of means to protect the ramp against false energisation in electrified areas.

The Railway Executive after further consideration decided to develop the " compromise " apparatus, the first tests of which were carried out in the spring of 1949, and the results were sufficiently encouraging to justify a large-scale trial under fast-running main line conditions. The down main line between Barnet and Huntingdon on the East Coast route to Scotland was selected for the purpose and it was decided to equip sixty-five locomotives. Track magnets and engine receiver units supplied before the war for use in Scotland were modified for these trials, and Western Region cab units were sent to signalling contractors for modification and fitting of relays.

Good progress was made with installing the track equipment, but there was considerable delay in the supply of the modified cab equipment and, as the first few fitted engines came into service, it was found that the modified Great Western cab equipment could not give sufficient braking force with the different type of brake system in use in the Eastern Region ; this trouble was eventually overcome by further modification of the cab equipment on the " vacuum " side. Difficulty was also experienced in locating the various components in the Eastern Region cabs, where they could be best protected from vibration and the ingress of dirt and dust. As a result, the trials did not get into full swing until December, 1950, when fifty-four engines had been fitted with a modified apparatus.

The trials continued during 1951, but the alteration of the original Hudd receiver unit to work electrically introduced many technical problems, although it had already proved its reliability on the Tilbury line under pneumatic operation. There was no great difficulty with the track equipment, but the electrical equipment in the cab was necessarily more complex than the standard Great Western type and a succession of safety side failures proved very difficult to trace to their source and eliminate.

The Executive therefore decided in April, 1951, to appoint a small committee of technical officers to carry out a thorough investigation on more systematic lines. Special testing apparatus was devised by the committee which proved very valuable in tracing the source of each failure and they were eliminated one by one by minor changes of design and by improving the workmanship of wiring and other details. Further failures which occurred in the first few months of 1952 were more easily dealt with, and by August, 1952, drawings for what was hoped would be the final prototype design were completed and the first set was fitted to a locomotive and put into service on October 17, 1952. In the meantime the accident at Harrow had occurred.

By the end of March, 1953, fifty-four locomotives had been fitted with the final prototype design. The details of its working were thoroughly examined by the Inspecting Officers of Railways, who witnessed its working on two occasions in March and April from the footplate of an engine hauling a twelve-coach train between King's Cross and Huntingdon. On both of these trips the equipment operated satisfactorily at all the semaphore distants and the multi-aspect colour-light signal locations which were passed at caution and clear ; it stopped the train within a safe distance with no action by the driver when an outer distant at caution was passed at 93 m.p.h., although the regulator was left open during the stop with the reversing gear at 35 per cent cut-off.

This report is not the place for a detailed technical description of the apparatus as finally designed, but the following is a brief summary of its layout and functioning from the point of view of train operation. The track equipment, consisting of a permanent magnet followed closely by an electro-magnet, is situated approximately 200 yards on the approach side of each semaphore distant and multi-aspect colour-light signal. Semaphore stop signals are not equipped. A bell is sounded in the cab for two to four seconds when a semaphore distant is clear or a multi-aspect signal is showing green. When a semaphore distant is at caution or a multi-aspect colour-light is at double yellow, yellow or red, the siren sounds and a brake application commences. The siren and brake can be cancelled by the driver as proof that he is alert, but an attempt to forestall the warning by premature operation of the cancelling handle can only result in a brake application. When the cancelling handle has been used a visual indication appears in front of the driver, and remains until it is reset to normal as the engine passes the next set of track apparatus. This valuable reminder is a feature of the London, Midland and Scottish system, but is not available in the Great Western system.

In my opinion, the apparatus should do all that is required of it in accordance with the principles of warning control, and there should be no objection to the same footplate indication for the caution and danger indications of a multi-aspect signal, bearing in mind that automatic train control must always be regarded as an auxiliary to personal observation of the signals and not as a substitute for it. The location of the track apparatus 200 yards before reaching

the signal gives the necessary warning in good time, and in multi-aspect areas no driver, except in a sudden emergency, will encounter a signal at red without having received an audible warning for the yellow aspect of the signal at rear, of which he will be reminded by the cancellation indicator while he is running between the two signals. I consider that, from the safety point of view, there is no need for differentiation on the footplate between the yellow and double yellow indications at a four-aspect signal.

Furthermore, from what the Inspecting Officers have seen of the latest prototype apparatus, on the bench and on the road, it appears that the technical principles are satisfactory, and that detailed design has now reached a stage when any unforeseen troubles which may arise should be rectified without undue difficulty. It will, however, have to be very fully tested in day-to-day service before the Railway Executive can say that they are satisfied beyond any doubt on the complete integrity of design and construction. Trials with this object commenced in April this year with the fifty-four engines, and the Executive feel that it will be necessary for them to be in full and normal service for at least six months, and that a final decision on the design for large-scale production cannot be taken until the results of the trials are assessed. In my view, the period may have to be longer, and thereafter further trials and laboratory tests to destruction under severe vibration, may be necessary with the production design.

The British Transport Commission have now informed the Minister that, on hearing that I, as Chief Inspecting Officer, am completely satisfied with the efficiency and reliability of the system, they will be prepared at once to consider financial authority for a practical programme of installation. The following are the Railway Executive's proposals :—

(1) For a five-year plan at an estimated cost of £7·5 million, and

(2) For a long-term plan, which, including the five-year plan, would bring the estimated total cost to £17·3 million.

The corresponding annual charges are estimated at £1 million and £2·2 million.

The five-year plan (1) would cover 1332 miles of route " or such part of it as may be deemed advisable," covering the lines from Euston to Glasgow, King's Cross to Edinburgh, Edinburgh to Glasgow, Euston to Birmingham, Manchester and Liverpool, Liverpool Street to Norwich, and Waterloo to Exeter, Southampton and Bournemouth. It is obviously desirable to avoid the dissipation of resources over too many routes at once, and in consequence the five-year plan would probably concentrate first of all on the main East and West Coast routes to Scotland (King's Cross to Edinburgh and Euston to Glasgow). The route priorities proposed are essentially sound, and I refer later to the suggestion by the Commission that the five-year plan should be regarded as a maximum rate of progress having regard to other commitments of the signal engineering staff in new work and maintenance.

The long-term plan (2) would cover an additional 3988 route-miles or, including the five-year plan, a total of 5320 route-miles ; on its completion 6713 route-miles would have been covered by warning control of one type or another, including the 1393 route-miles of the Western Region and the London Tilbury and Southend section which are now equipped. These 6713 route-miles represent nearly 35 per cent of the British Railways total (19,276 miles) and would include practically all the main lines carrying heavy passenger traffic. The existing proportion in the Western Region is very similar.

Thus, after all these years, there are now firm prospects that work will be started on the extension of warning control to all the important routes of the country within a measurable time, but it would be wrong for pressure to be exerted on the Commission or the Executive to embark on a very costly programme before the trials are completed to the satisfaction of all concerned.

In reviewing the history of automatic train control in this country to date which has been summarised in the preceding paragraphs, credit must be given to the former Great Western Railway Company for developing its contact system so early and installing it so extensively without pressure from Government recommendations, and there is no doubt that it contributed in no small measure to the notable safety record which has been continued in the Western Region. The London, Midland and Scottish Railway came into the field much later, and on a smaller scale, but its pioneer work with non-contact equipment has now proved very valuable.

Accidents which occurred soon after the war again led to strong recommendations for warning control in the inquiry reports, but the railway companies were then nearing the end of their existence as independent concerns. They were not in a position to take decisions on such an important matter of technical policy, and the matter was left to the British Transport Commission and the Railway Executive when they assumed control in 1948. The Commission was not slow to decide that the important lines of British Railways should be equipped with automatic train control, and it then became a question of ways and means.

The Railway Executive were thus faced with a decision on the system to be adopted. There was the well-tried contact system introduced by the Great Western Railway long before inductive methods became feasible with the development of special magnetic steels, and the London, Midland and Scottish non-contact system which had only been proved under pneumatic operation with barely sufficient differentiation between the audible signals for caution and clear. The decision was theirs, and I do not think that they can be criticised for adopting the more modern non-contact method of pick-up as a long-term future standard for the reasons I have mentioned above, despite the obvious attractions of the Great Western system which could be applied at any rate to other steam lines with comparatively little modification. As the London, Midland and Scottish system was unacceptable as it stood, this decision required an entirely fresh design of locomotive equipment to give the distinctive Great Western audible signals in the cab in response to the Hudd type magnetic receiver.

This inevitably led to further delay before a practical programme could be started, but the Executive did not anticipate at first that the development stage would be so prolonged, as the electrical circuits proposed were conventional, and the majority of the components had been well proved in other applications. As it happened, their combination for this special purpose under the rough conditions of locomotive operation gave rise to one problem after another, which had to be solved by continual redesign and manufacture of special parts at a time which was not favourable to such work owing to the export and rearmament programmes and the acute shortage of technical staff, with the result that four years were taken to bring the prototype equipment to its present advanced stage.

I have been furnished with full details of the troubles which were encountered and of the successive steps which were taken to overcome them, and I would not be prepared to say that the experimental period could have been greatly shortened ; it should also be recollected that ten years elapsed before the L.M.S. Hudd type apparatus became thoroughly reliable. Progress, however, seems to have improved when the Railway Executive put the experiments on a more systematic footing by the appointment of a special technical committee in 1951. While it is only natural and proper that the grave consequences of the accident at Harrow should have strengthened the anxiety of the Commission and the Executive to pass on to practical achievement as soon as they can, I would draw attention to the fact that the final prototype design was ready two months before it occurred.

There is thus no longer any need to urge the adoption of automatic train control as a standard feature of safety equipment, as is shown by the proposals which have been outlined by the British Transport Commission. They have, however, emphasised that while automatic train control deserves high priority among safety measures, it cannot be given absolute priority over other forms of signalling modernisation, such as the extension of track circuiting and block controls to prevent mistakes by signalmen ; these also are included in the Ministry of Transport Requirements for new work and renewals. Progress in this direction has been continuous in recent years, though circumstances have prevented the realisation of the comprehensive programme which, as I have mentioned earlier in this report, was envisaged by the Railway Executive in 1948. As an example, the West Coast main line of the former London, Midland and Scottish Railway, on which Harrow is situated, has been more thoroughly equipped with modern signalling controls than any other long-distance route in the country ; these are one of the " indirect " methods of improving safety recommended by the 1927 Pringle Committee, and statistics confirm that they have been very effective.

This work must, of course, continue as a means of preventing accidents of a numerous class in proportion to the total against which automatic train control can provide no safeguard. Encouragement must also be given to the progressive replacement of semaphores and manual block by colour-light signals and continuous track circuiting on lines where traffic is dense and at complicated layouts, as another of the indirect methods. Although these improvements are designed in the main to prevent signalmen's errors, colour lights, including colour-light distants in semaphore areas, have done much to help drivers, especially at night and in bad weather, and their number has been increased by 50 per cent since 1948. Experience, however, has shown that they cannot by any means be regarded as an equivalent alternative to automatic train control.

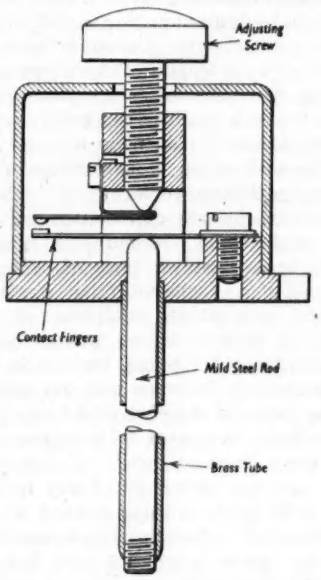
The safety of railway operation depends on many factors, and besides modern signalling equipment they include a good track and soundly constructed and maintained rolling stock. The provision of automatic train control is only one of them, and the proportion of accidents which it can prevent is comparatively small, but they are of a type which can be disastrous to life and very costly to the administration, and therein lies its special value as a safeguard against the consequences of human failure.

In the regulation and execution of an automatic train control programme in relation to the many other calls on the signal department for new work and maintenance, much must be left to the judgment of the management. I do not, however, look on automatic train control as a competitor to other signalling development, but as complementary to it, as indeed was the view of the Railway Executive in 1948, when they recommended that a more extensive programme than that now proposed should be completed in six years, and that it should run concurrently with a programme of the same order for the extension of track circuiting and block controls. I would also emphasise that, in contrast to the many effective devices which have been developed and so widely installed over the years to assist signalmen in their work, the safety of traffic on the majority of our lines still depends on the personal vigilance of the enginemen, as in the earliest days.

The very occasional failures which have occurred give no grounds for loss of confidence in British railway engine drivers as a whole, and there is no reason to believe that the problem has become more urgent in the last few years, notwithstanding the exceptionally tragic results of one such failure at Harrow. All, however, are agreed that enginemen should be given their share of technical aids to safe working, and I consider that at this late stage there should be no reservations on the rate of progress once the apparatus has been approved. I therefore recommend that all the resources which are available to the railways for the purpose should be directed to the timely accomplishment of the five-year plan and its subsequent extension as proposed, without prejudice to other necessary signalling work. The estimated first and recurring costs are large, but in my opinion the expenditure should be faced without hesitation, and no financial considerations should be allowed to stand in the way of an ambitious programme, in view especially of the arduous railway conditions in this country with its dense traffic, high speeds and adverse climate in the winter months.

Temperature and Humidity Control Equipment

AN exhibition of temperature and humidity control methods was held last Monday at Caxton Hall, Westminster, by P.A.M., Ltd., Merrow, Surrey. The methods of temperature control demonstrated depend on the "Tem-Con" system developed by the company, of which the sensitive element is illustrated herewith. It consists of a bimetal unit in the form of a rod within a tube, the rod having contact with the tube only at the lower end where it is secured. It can be seen that differential expansion of the rod and tube operates the beryllium-copper contact fingers. The upper finger can be hand adjusted by the control screw so that a precision contact can be obtained for any position assumed by the lower contact as determined by the temperature of the environment it is desired to maintain. The electrical loading on these



"Tem-Con" Sensitive Temperature Element

silver-tipped contact fingers when closed is of the order of 0·00005 amps so that a movement of two micro-inches is sufficient to actuate a relay without any arcing.

When the contacts are closed, the very small, low-voltage current is amplified by a simple and robust electronic circuit to excite a relay mounted on the amplifier chassis. This relay carries the heating current and may be one of three standard patterns. No adjustment or control is required by the amplifier, which is enclosed in a compact metal case. It may be installed at the most convenient point and connected to the element by a pair of conductors of any required length. A 200–250V a.c. supply is required by the standard amplifier, from which it will draw some 6W in addition to the intermittent heating current passing through the relay. All the components, including the relay, are mounted in sockets on the chassis. Where two or more elements are within reasonable distance of each other, multiple amplifiers are recommended, which are made in units suitable for dealing with from two to five independent circuits.

The electronic relay is designed for an operating current of approximately 60 micro-amps at up to 1V. It is unaffected by voltages induced in the primary contact leads even if these are hundreds of feet long and will switch currents up to 8 amps at 200–250V a.c. Although normally instantaneous in operation a delay either fixed or variable can be easily introduced. The relay can be supplied to switch off with breaking or making primary contact, or with single pole change-over switching. Socket-fitting of all electrical components is arranged to permit their rapid interchange or replacement.

The multi-circuit assemblies, available in self-contained units of from two to five independent relay circuits, are fitted with colour coded terminal blocks and a fuse in each switched circuit. High resistance leaks in the primary circuit insulation cannot produce spurious operation and primary contact resistance can be relatively high and variable without affecting operation. No thyratrons or thermally operated switches are used. It is stated by the company that temperature control can be maintained between limits of ±0·2 deg. Cent.

For the temperature control of moving hot surfaces such as rolls, a radiation element is employed. The bimetal tube and rod element is replaced in this unit by a flat, tensioned strip of high expansion metallic foil which is suspended by its ends in a casing. One side of this strip is arranged to "see" the hot surface, the casing protecting it from draughts and other sources of radiation. It is stated that control within 2½ deg. Cent. can be arranged with this unit.

The mechanical construction of the temperature sensitive elements has been adapted to produce an extremely sensitive and stable humidity control which in conjunction with the "Tem-Con" electronic relay will provide control of R.H. to within ±½ per cent.

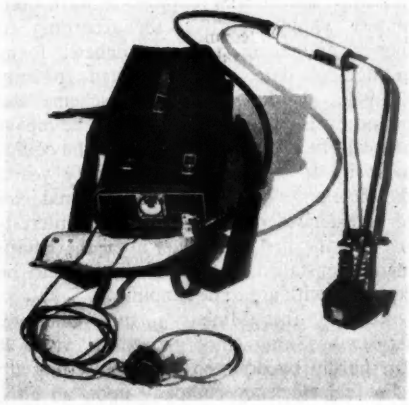
The humidity element is a short piece of vegetable parchment. Mechanical protection with adequate ventilation is provided by a slotted metal sheath. These controls will operate consistently at 95 per cent R.H. at 110 deg. Fah. and also in conditions of dryness such as 10 per cent R.H. The elements are provided with an adjustment knob permitting a range of operation of about 40 per cent R.H. and they can be supplied calibrated to operate over that range anywhere between 10 per cent and 100 per cent R.H.

The "Tem-Con" system is easily adapted to respond to any small movement and by means of suitable mechanical devices, changes of pressure, linear dimensions, humidity and liquid level can be detected by this simple system.

Ultrasonic Equipment for Detecting Flaws in Rails

IN Great Britain visual methods are normally used for inspecting rails for cracks and head and web separations. Visual inspection suffers from the disadvantage that the cracks cannot be detected until they have reached considerable size, and then only when they are not hidden by dust and dirt.

Means of detecting flaws by ultrasonic beam have recently been developed and London Transport now has in use one such instrument—the "Audigage" flaw detector, a product of Branson Instruments Inc., of Stamford, Connecticut, U.S.A. This test set consists of a small battery-operated ultrasonic frequency generator

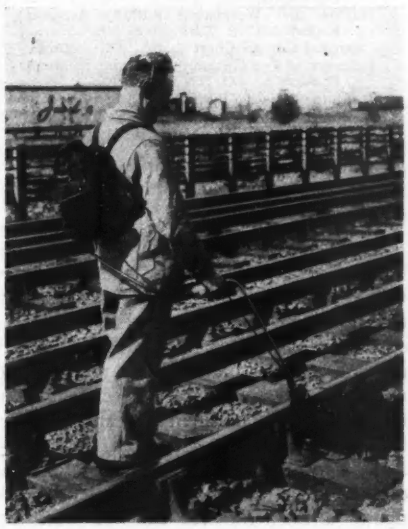


The "Audigage" Flaw Detector

and receiver, carried in an 11½ lb pack on the operator's back, a crystal in a special holder on the end of a long handle, and a pair of headphones, as illustrated in the photographs reproduced herewith. The crystal is applied to the head of the rail and the presence of a crack is indicated by a lowering of the continuous tone produced in the 'phones by a perfect rail.

Power is obtained from three 1½V and two 67½V batteries and the instrument contains three "IU4" valves carried on a shockproof sub-panel in the main housing. Mounted on the housing are tone and volume controls, a milliammeter for battery testing, a jack socket for the headphones and a multi-point connector for the crystal. The main "On/Off" switch is a mercury contact in the crystal housing, and switches the set on only when the crystal container is held in the vertical position as for use. The set cannot be switched on if the crystal cable is not connected.

The instrument is placed in the knapsack, control panel upwards, the headphones are plugged in and the crystal cable is connected so that it will trail normally over the operator's shoulder. The crystal is placed on the railhead, a thin film of oil having first been spread on the latter to give good contact. Tone and volume are then adjusted to suit the operator, who then moves the crystal along the rail surface, making sure that the length of the crystal lies transversely across the rail. The ultrasonic beam travels down through the rail until it meets a surface



Ultrasonic Detection of Rail Flaws

that will reflect it. Normally, this is the bottom of the rail, but in a cracked rail the wave is reflected by the flaw, and a change in tone—or loss of tone—is produced in the headphones. The nearer the crack to the head of the rail, the greater is the drop in frequency. If a crack is not substantially parallel to the head, the tone ceases altogether and no indication of the depth of the crack from the top of the rail can be obtained, but its length is, of course, gauged from the distance covered by the crystal during the "no tone" period. The presence of fishplates does not affect the proper operation of the device, as bolt holes give a characteristic, and quickly recognised, tone. Small cracks immediately under bolt holes cannot be detected, however, because of the interruption of the beam by the holes themselves. Normal field maintenance of the instrument consists of testing and replacing batteries and replacing valves. Occasionally, also, the plastic strip protecting the crystal requires renewal.

The instrument has been in use by London Transport for about three weeks, during which time some 15 miles of rail have been inspected with it. Several minor defects which were not revealed by visual inspection were discovered in sections of rail covered by the fishplates.

MACHINING THE NIMONIC SERIES OF ALLOYS.—A new edition of the publication *Notes on Machining the Nimonic Series of Alloys*, which has just been issued by Henry Wiggin and Co., Ltd., contains additional information on drilling and is extended to cover the newer alloys, Nimonic 90 and 95. This publication provides general guidance based on practical experience and makes reference to various tools and cutting oils which have been proved successful. Suggested speeds and feeds are given for each operation, together with diagrams of profiles and tool forms taken from actual machining operations. Copies of this handbook are available from the firm's Publications Department at Thames House, Millbank, London, S.W.1.

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ECONOMIES IN COAL USAGE

For the first time since the war there was at this time last year no anxiety about the sufficiency of coal stocks to outlast the coming winter. But this year that anxiety is again being felt, and we are very glad to read that the situation has been and continues to be discussed in Parliament. For, though it is much too early in the year to make any definite forecast that another coal crisis will occur next winter, this year's figures already threaten such an outcome. For the first twenty-five weeks of this year saleable output of coal at 110,692,800 tons is actually less than the corresponding output last year of 110,782,900 tons. But consumption at 108,348,000 tons this year substantially exceeds that of 1952 at 105,314,000 tons and total distributed stocks are more than 1,250,000 tons lower this year than at the same time last year. Nor is that all. It has been estimated that, as compared with last year, an output equivalent to 3,500,000 tons will be lost as a consequence of the granting to the miners of two weeks' holiday instead of one. In short, the rate of consumption of coal by industry, which was held back last year by other raw material shortages, is now rapidly recovering, whereas, despite some improvement in the rate of production in more recent weeks, the output of coal is showing little or no improvement.

That there should be any very rapid increase in coal output this year, or even over the next few years, is unfortunately very unlikely. Various estimates have been made of the deficiency of supply as against the real demand. But all of them have it in common that the estimate of demand far exceeds any rate of output that can be envisaged as possible within the next ten years, and very probably within the next twenty. The need remains, therefore, and is likely to continue to remain for very many years to come, to lower the demand by promoting economy in coal usage. In last week's issue we noted actions which the Government is now taking to that end. On the basis of the report of the committee under the chairmanship of Sir Harry Pilkington, whose terms of reference were to work out a scheme for increased fuel efficiency advisory services in industry, the Government has approached the British Productivity Council and that body is to form and sponsor a fuel efficiency company. That company will receive annual contributions totalling at least £450,000 from the National Coal Board, the British Electricity Authority and the Gas Council, and it will take over and rapidly expand fuel efficiency advisory services hitherto performed by the Ministry. In addition changes are to be made in the scheme started about a year ago under which £1,000,000 was set aside for loans to industrialists to encourage the installation of fuel saving equipment. These loans were to be made at commercial rates of interest. The scheme appears to have been almost wholly abortive, for according to figures quoted in a recent debate, loans granted to date have amounted to only £25,960. Under the revised scheme the period during which the loans will be repayable will be extended to the life of the equipment up to a maximum of twenty years, the categories of equipment covered are to be extended, the loans are to be interest-free for the first two years after the equipment is installed, and the formalities to be complied with are to be simplified.

Because the Ministry's fuel efficiency service has long since proved its value it can hardly be doubted that the setting up of a fuel efficiency company upon an altogether larger operating scale will effect correspondingly larger economies. But much less assurance can be felt about the success of the changes in the loan scheme. It is true that the Pilkington report stresses the need to provide financial incentives to encourage industrialists to install fuel-saving equipment. But it is not easy to do it effectively. For in firms which are not heavy coal users the cost of fuel may be so low in relation to total costs that economies promised by the replacement of existing inefficient appliances may justify neither the capital expenditure involved nor the possible disturbance to production while the work is being done. Moreover, the incentive is sometimes active in promoting rather than preventing waste. It may, for example, be appreciably cheaper in overall cost to burn more fuel for heating than to insulate the walls of a building against heat losses. Furthermore, it is by no means simple to draw up a satisfactory list of those appliances to which the loans scheme should be related, nor is it certain that their use will necessarily lead to economies. For economy in fuel is to be sought not only through the use of appliances that are efficient in themselves, but even more through attention to detail in insulation, the recovery of waste heat, the prevention of undue condensation in lengths of steam pipe and in literally hundreds of other detail ways. What financial incentive can be offered to a firm to devote that attention to detail when the financial saving brought about will be almost negligible anyway? If economy of fuel was the only desideratum the surest way, undoubtedly, of bringing it about would be to raise the price of coal. But even so, if a significant result was to be attained amongst the multitude of small industrial users not at present greatly influenced by coal prices, the rise in price would need to be steep and the action of raising prices so sharply would have deplorable effects upon costs in industries which are heavy users of coal. Certainly the Government's actions are likely to bring some relief of the pressing demand for coal. But there will equally certainly be no dramatic fall. Indeed, it appears to us that relief within a few years time may come from quite another factor. The new oil refineries in this country are now producing ever larger quantities of high-grade spirit. As a direct consequence they need, too, to dispose of residue oils. Present industrial users of coal may increasingly discover that for their purposes, oil, by reason of its cleanliness and ease in handling, has advantages. No doubt, the financial incentive to improvement being small or non-existent, they will continue to waste heat. But the pressure upon limited coal supplies will be relieved.

ELECTRICITY AND INDUSTRIAL PRODUCTIVITY

Industrial productivity in Great Britain as influenced by the use of electricity, formed the theme of papers discussed at the British Electrical Power Convention in Torquay last month. A broad survey of the whole field was given in Colonel B. H. Leeson's paper on "Electricity and National Prosperity," and the part played by electricity in industrial production was analysed in Mr. E. R. Wilkinson's paper, abstracts from which appeared in our issue of June 12th. It is common knowledge, of course, that industry in the U.S.A. is more highly mechanised than that in Great Britain, and Mr. Wilkinson produced evidence suggesting that, as far as American industry is concerned, "the rate of increase in productivity becomes faster as mechanisation becomes more comprehensive." For example, he showed that, between 1909 and 1949, the installed horsepower per operative worker was increased

in the U.S.A. two and a half times ; but the volume of industrial output per man-hour increased more than fourfold. The conditions under which British and American industries operate, however, differ so very widely that it would be rash to assume that results achieved in America can readily and universally be obtained in Great Britain. The urgent need for greater mechanisation of British industry, with the help of increased electrification, cannot be questioned. What is very doubtful, however, is whether the yardstick of " horsepower per operative worker " is satisfactorily applicable as a means of comparison. Certainly it seems to us too crude a means of measurement to be applied universally to British industry.

Based upon " horsepower per operative worker," Britain's use of industrial electric power would have to be increased threefold, over industry as a whole, to reach the American level. But, as Mr. Wilkinson himself points out, the whole question must be examined in much closer detail before the true extent of the British deficiency can be assessed. Nor can the deficiency be measured merely in terms of shortage of horsepower, as represented, say, by the induction motor. At least as important in raising productivity as the direct use of power in manufacture are the rapidly advancing techniques of instrumentation and automatic control by electronic and other devices, whereby many industrial processes can be greatly speeded up. A spectacular example is to be found in the continuous production of metal strip. Similar trends are to be seen in the elaborate production lines at the Austin motor works, where the entire process of marshalling the various assemblies and feeding them to the production lines according to the desired programme is controlled automatically by a punched card system. Equally significant, perhaps, are the potentialities of electronic computing machines in reducing, perhaps by many months, the time required in design calculations relating to new or prototype aircraft, for example. In the highly competitive field of aircraft manufacture the saving of computation time may be of inestimable value. Yet, in relation to the man-hours of work saved, these devices use almost negligible amounts of power.

Although technological improvements such as these can save many man-hours in large works, and in particular industries, they are less generally applicable to the multitude of smaller works employing 100 or so workers and representing a great diversity of industries. There is, however, one amenity—an improved standard of lighting—which could, we believe, transform the productivity of some of these smaller works, without imposing a heavy burden in capital outlay or running costs. In the lighting of Britain's factories and workshops there is a wide gulf between the good and the bad. The best-lit factories are exemplary, the worst are depressingly gloomy to an extent that cannot but result in poor productivity, both in the offices and in the shops. Bad lighting in these days is a reproach to our industrial well-being. It is all the more a reproach in that it can be so readily remedied. For, with the technical resources of the Illuminating Engineering Society, the E.L.M.A. Lighting Service Bureau, and the manufacturers, there exists in this country, second to none, a wealth of knowledge and " know how " about the art of lighting and the means of applying it to the best advantage. We can think of no surer way of raising productivity generally than by investing in better lighting.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

LOCOMOTIVE WORKING IN GREAT BRITAIN

SIR,—At the beginning of his article of May 29th, Mr. Nock asserts that the Peppercorn " Pacifics " were not originally very " free-running " machines, and sundry modifications to the valve setting were necessary to remedy this deficiency. I do not recall that details of their lead and exhaust lap have ever been published, but it is reasonable to assume that traditional L.N.E.R. practice was followed. If this is so, it is incredible that such a setting could have been any detriment to free running, for 1⅛in lap, ⅛in lead, zero exhaust lap and 8 per cent clearance volume is about the best that can be done with Walschaerts gear for general express passenger work, and these dimensions have for many years past proved sound in practice. It would therefore be desirable to know what the original and the final valve setting actually were and how they influenced running in the manner suggested.

Later Mr. Nock gives details of a big effort from Werrington to Stoke which is said to have been made in 12 per cent to 15 per cent cut-off. In the present state of knowledge, it is impossible to estimate the power output of locomotives with very great accuracy, especially if atmospheric conditions are not exactly known, but a fair average figure for the mean horsepower required is 2280, 1490 of which is needed at the tender drawbar. It is probably impossible that wind could have eased the locomotive work to the extent of some 650 h.p.; a genuine cut-off of 15 per cent can produce little more than 1500 on an " A.2/3 " at 65 m.p.h. Admittedly 12 per cent would just about produce the 2280 or so required with an ideal diagram, but no doubt the real figure was 25 per cent to 30 per cent on this occasion.

It is mentioned that Driver Hogarth linked up from 13 per cent to 12 per cent at one point between Inveresk and Dunbar. The index plate on an " A.1 " is graduated at 10 per cent intervals from 75 per cent to 15 per cent, but not at all between the latter and mid-gear. This indicator was probably also incorrect ; but, even if it were accurate, and cut-off altered 1 per cent designedly rather than accidentally, so meticulous a technique would seem to demand equally precise recording. Unsuspected dangers, both to official and lay recorders, lurk in those cryptic words " mid-gear." On the Gresley " Pacifics " cut-off at mid-gear is 3½ per cent ; on many engines it is more than this ; if the lead of an " A.1 " is unknown, one cannot determine the cut-off at mid-gear. For this reason alone interpolations in the region of mid-gear are of dubious value.

Such accessories as steam chest gauges and cut-off indicators, intended only as a rough guide to drivers, are erratic in ordinary service, and there seems little point in making a detailed record of their vagaries.

There is, moreover, usually no good reason for operating Walschaerts gears at a shorter genuine cut-off than 15 per cent ; expansion ratio normally at its maximum here, diminishes towards mid-gear and cylinder efficiency with it.

As regards efficiency of the " A.1 " class, it has often been complained that they are appreciably heavier on coal than the Gresley "Pacifics." This criticism is the more surprising in that the Kylchap " A.4s," as might be expected, seem to have been appreciably more economical than the standard engines, but it may have no statistical basis. When opened out, however, the " A.1s " appear to eject a good deal of unburnt coal from the chimney ; it may be surmised that the fierce blast arises from the dimensioning of the blast pipes for moderate power output only and is perhaps the chief factor in heavy coal consumption.

There seems to be no evidence that the " A.1s " were ever not free-running machines ; but, in comparison with the " A.4s," which attained up to 107 m.p.h. in ordinary service, they owe to their clumsy contours a high air resistance that may well explain a distaste for similar exploits.

J. D. MUNNION

Chelmsford, June 11th.

EDUCATION FOR DESIGN

SIR,—I agree with Mr. McKenzie, in your issue of May 29th, that heredity and not education might deserve the credit for the able designers mentioned by Sir David Pye, who had entered the industry direct from school. The point that I was making, however, was that this kind of able man now has little chance of avoiding the university, and consequently that it is up to us in the universities to see that the spirit of design is not stifled in him.

I also agree with him that training in design should be given by those who have the requisite engineering experience ; where we part company is that I consider that it should be done in the universities, and that our staffs, who are already recruited from those with engineering experience, should be encouraged to keep it up to date by consulting practice.

Mr. Frost's letter in your issue of June 5th is also largely in accord with my views ; I am unconvinced, however, by his arguments in favour of the part-time lecturer and categorically opposed to the view that so important a subject can be left to " a junior designer who is himself a graduate," who has in general neither the experience nor the degree of responsibility required : in this Mr. McKenzie would probably support me. Further if, Mr. Frost will re-read what I said he will find that, contrary to the implications of his letter, I am convinced myself that design must be taught by a designer. Where we differ is that I want him to be a member of the university staff; Mr. Frost wants him on loan from industry.

I find it difficult to take seriously Mr. Frost's suggestion that design classes be held outside normal working hours, i.e. 9 a.m. to 5 p.m., Monday to Friday, and 9 am. to 12 noon on Saturday. Eliminating the vacations, during which works experience is to be gained, and the week-end, means, plainly, that evening classes are advocated. With our overcrowded curricula this would mean encroaching on the only time left to the student for reading and writing up notes and laboratory work and would be a thoroughly retrograde step. Finally, may I assure Mr. Frost that he is wrong in supposing that I have not fully considered the possibilities of the part-time lecturer ; I have been one in the evenings at a technical college and I have seen it tried here. My conclusions are those given in my lecture.

EWEN M'EWEN

King's College, Newcastle upon Tyne, 1,
June 19th.

TURIN ENGINEERING CONGRESS.—A preliminary programme of the fifth International Mechanical Engineering Congress has now been prepared. This congress will be held at Turin from October 9 to 15, 1953. Its theme is to be " Production and Assembly Methods for Components in Mechanical Engineering." The British Engineers' Association, 32, Victoria Street, London, S.W.1, represents the United Kingdom interests on the Organising Committee of the Congress.

Obituary

Dr. ROBERT SULZER

In a short announcement in our last issue, we recorded with deep regret the death of Dr. Robert Sulzer, which occurred, suddenly, after a heart attack, on Friday morning, June 19th, in his office in Winterthur, Switzerland. Dr. Sulzer, who had celebrated his eightieth birthday earlier this year, had been closely concerned throughout the whole of his distinguished engineering career with the affairs of the family firm of Sulzer Brothers, Ltd., Winterthur. Although, of course, the greater part of his time was spent in Switzerland, he paid frequent visits to this country and was consequently well known to many British engineers.

Robert Sulzer, who was born in 1873 in Winterthur, was the second son of Heinrich Sulzer-Steiner, who was for many years the head of the Sulzer firm. For the early part of his education, Robert attended secondary and industrial schools in Winterthur and Lausanne. Subsequently, he studied at the Swiss Federal Institute of Technology, Zürich. There, he took a diploma in engineering in 1898, and remained at the Institute for a further year to act as assistant to Professor Stodola. This was followed by periods of practical engineering training in Great Britain and in the United States of America, and by visits to Japan and India. Robert Sulzer entered his family's engineering business in Winterthur in 1901 and was admitted to partnership in 1906. In 1914, the business was converted into a limited liability company and from then onwards Robert Sulzer was a valued member of the committee of managing directors of the firm. He retired from membership of that committee in 1941, but right up to the day of his death he had remained intimately associated, in an advisory capacity, with all the Sulzer activities.

Robert Sulzer

As a young man, Robert Sulzer was keenly interested in design problems, especially those connected with steam engines and pumps. Nevertheless, the workshops and foundry were his chosen domain, and in them, it may be said, his most important work was done. He maintained firmly his family's tradition of high standards of quality, though he always preferred clear and simple designs. Those who were closely associated with Robert Sulzer recall his power of memory, and his familiarity with every detail of the machine tool equipment in the Sulzer works. At the same time, he was always amenable to suggestions and ready for innovations. After the death of his elder brother, Carl Sulzer-Schmid, Robert Sulzer was for some years responsible for technical developments in most branches of his company's organisation. One example of his energetic work in the field of development is a weaving machine produced by the company.

In addition to the services rendered through the years to his company, Robert Sulzer was at all times ready to assist in other spheres of engineering activity. He belonged to many technical societies and committees and at different times presented papers to engineering institutions in Great Britain, France and Holland. In particular, we recall a paper to the Institution of Naval Architects in March, 1926, entitled "Temperature Variation and Heat Stresses in Diesel Engines." For that paper Dr. Sulzer received a gold medal and was made an honorary corresponding member of the Institution.

Another important paper by Dr. Sulzer was that on "Recent Measurements on Diesel Engines and Their Effect on Design," which he presented to the Koninklijk Instituut van Ingenieurs, Rotterdam, and which was reprinted in The Engineer of March 31, 1939.

Robert Sulzer's work and his great knowledge of engineering were deservedly recognised in 1941 when his honorary doctorate was conferred by the Swiss Federal Institute of Technology. He will be remembered, however, not only on account of his outstanding technical ability. He valued the human qualities and the work of all his employees, and took a profound interest in their social welfare. During his years of responsibility at Winterthur, Dr. Sulzer was instrumental in the building of many hundreds of houses for his firm's workpeople. In this and in many other ways, he won the confidence and esteem of those who worked for the firm. Robert Sulzer was an eminent engineer who will be greatly missed; but his work and example cannot fail to be an inspiration.

Organisation of Some Nationalised European Railways

Under the Transport Act, 1953, the Transport Commission is required to formulate a scheme for the decentralisation of the railways of this country. As a matter of interest we have obtained from official sources some particulars of the manner in which the nationalised railways of France, Italy, Norway and Switzerland are organised and administered. These notes, although not in great detail, show the general pattern of administration developed for railway systems which have been nationalised for very many years. The systems of administration resemble each other closely in many respects.

The French National Railways

The amalgamation of the main railway systems in France, to form the national undertaking—Société Nationale des Chemins de Fer Français—was not effected until 1938. Under the decree passed in 1937 to bring about this amalgamation, 51 per cent of the shares are held by the State and 49 per cent are privately owned.

The Minister of Transport is the member of the Government responsible for the railways. The S.N.C.F. is headed by an administrative board of twenty members, of whom ten are nominated by the State, five by the original railway companies, and five by the railway employees. The director-general receives instructions on matters of policy from the administrative board. The director-general, his two assistants, and the general secretariat are assisted by directors, each entrusted with the management of an individual section: general, research, personnel, operation, commercial, locomotives and rolling stock, ways and works and stores.

For purposes of administration the railway system is divided into the following six main regions, each headed by a director: Eastern, Northern, Western, South-Western, South-Eastern and Mediterranean. Each region comprises three departments, in addition to a welfare department—traffic, locomotives and rolling stock, and ways and works—and is subdivided into sections dealing with traffic, locomotives, rolling stock and way and works, which come under the regional departments.

There is an interchange of staff between headquarters and regional offices and also between the various regions. The appointment of senior specialist officers from the regions to headquarters makes directly available within the administration an intimate knowledge of the particular conditions within the regions and assists the executive in making its decisions.

The very restricted amount of money now available to the railways for the purposes of reconstruction and new investments has obliged the S.N.C.F. to examine very closely its technical projects and to reduce the extent of certain initial programmes. In this way the S.N.C.F. has restricted to a large extent its projects for the reconstruction of installations destroyed during the war, taking into account alterations in the kind of traffic which have occurred during the last fifteen years and the improvement in working efficiency; and [the scrapping of certain undertakings and retention] with single-line track of certain lines formerly double track.

Prior to nationalisation, standardisation of rolling stock was practised in a large measure by the original companies and at present all new coaching stock is made to a common standard for use throughout the system. Wagon stock is all built to the

standards laid down for inter-European operation. The last steam locomotive ordered from French industry was delivered in October, 1952, and there is no likelihood of new orders being placed for a long time ahead. In fact, the S.N.C.F. now has available enough steam locomotives for its needs. Furthermore, the programmes of electrification under way in the North and East of France (Valenciennes-Thionville line) and in the South-East (Ambérieu area), as well as the plans for further electrification still being studied (extension of the Paris-Lyon section to Marseilles and Nimes, and of the Valenciennes-Thionville section to the east and in the direction of Paris), will free a large number of steam locomotives, which will thus replenish the stock for many years to come.

The S.N.C.F. has concentrated on the question of economy in all its aspects and this has led to the development of a new method of electrification by means of single-phase, 50-cycle high-tension current (25,000V), which calls for much less costly installations than are necessary for the standard methods of electrification adopted up to now by the S.N.C.F. (direct current at 1500V). The use of industrial current also avoids the expense of installing special cables for carrying high-tension current to meet the needs of the railways. This method of electrification, tried out during the last few years on the Aix-les-Bains-La Roche-sur-Foron line, will be brought into operation on a large scale on the Valenciennes-Thionville line.

The Italian State Railways

The railway system in Italy was acquired by the State in 1905, when the Ferrovie dello Stato came into being. Under the present organisation the Minister of Transport controls the railways through a director-general and two vice-directors who are permanent officials. The minister is assisted by a Government-appointed advisory council of eighteen members, of which he is the president, and which is directly responsible for the working, equipment, new works, purchase of materials, &c., of the whole concern. The director-general has a technical and administrative headquarters staff in Rome, which supervises the fourteen regions (Compartimenti) into which the whole railway system is divided and regional officers (Capi Compartimento) are responsible to him for all matters of immediate local importance.

New works of any magnitude are not carried out directly by railway labour. contracts being placed with private firms which work to railway designs and requirements. Likewise, rolling stock and locomotives are built to railway requirements by private firms, which undertake major repairs and overhauls, the railway workshops being only concerned with running maintenance. No appreciable degree of rolling stock standardisation has been introduced on the railways of the country, probably owing to the widely differing conditions which exist on the lines.

The present shortage of money, the number of uneconomic lines which have to be maintained, and the results of damage during the war years, are all contributory causes of the somewhat unhappy financial conditions of the Italian State Railways. Although progress is being made with electrification, service improvement on popular lines, introduction of new carriage stock and special improvement works to encourage traffic, the losses incurred by the railways have steadily increased during recent years.

In certain quarters it is considered that an overall review of freight and passenger rates and an increase in fares would do much to improve the financial position of the railways, but the commercial and political repercussions this would bring about are such that any steps in this direction are unlikely.

The Norwegian State Railways

The Norwegian Ministry of Transport directly controls that country's railways through a director-general and an administrative board of directors, each of whom serves for a period of four years. Of this board three members, with personal deputies, are selected by the Government; two members with deputies are appointed by the King, and two members, also with deputies, are elected by ballot by the permanent staff from its own members.

At the headquarters of the railways there are eight main departments—administration, operation, track maintenance, electric, general stores, traffic, locomotive and economics—each under the control of one of the above directors. There are also a public relations office and a welfare office, which come under the direct control of the director-general. The headquarters staff makes decisions on all matters which do not come within the scope of a personnel and pension committee and those which it is not necessary to put before the Ministry of Transport or should be left for the district administrations to decide. Matters which need decision of a higher authority for constitutional reasons, or are of national importance, are placed before the Ministry of Transport for consideration. The personnel and pension committee mentioned above deals with staff matters such as engagements, transfers, discipline, pensions, &c., and consists of the director-general or his deputy and four members with deputies.

For operational purposes the railway system is divided into the following eight administrative districts: Oslo, Drammen, Hamar, Trondheim, Bergen, Kristiansand, Stavanger and Narvik. Of the 4400km of lines in the Norwegian railways system 1130km is at present electrified.

Swiss Federal Railways

The Swiss Federal Railway—the Schweizerische Bundesbahnen or Chemins de fer Fédéraux Suisses—controls just over half the 3500 miles of track in the country, the remainder of the lines being owned privately by some 176 independent companies. All the important main lines are owned by the nationalised body and practically the whole of its system is now electrified.

Direct supervision of these railways is entrusted to a Government appointed administrative council of fifteen members corresponding roughly to the former boards of directors of the British railway companies. This council is responsible for the control, appointment of departmental heads, general organisation, issuing of regulations, &c. General direction of the railway under the council's authority is carried out by a general management comprising three members working on a council basis with the president acting as chairman.

The general management council has its offices at the Berne headquarters of the railway and, for purposes of administration, the system is subdivided into three main regions with directors at Lausanne, Lucerne and Zurich. These regional managements deal independently with most problems affecting their regions, within rules and regulations established by the general management.

All purchasing for the system—with the exception of rolling stock and certain major items of equipment—is done through a central stores department at Bale; this not only enables a measure of economy to be practised but has made it possible to standardise to a large extent the materials and equipment used throughout the regions.

This department is in close touch with the research and development sections, and is kept in line with the latest methods, materials and equipment. In this way, through the central stores, all regions are supplied with the best materials and equipment to maintain uniformity in practice and economic and efficient working.

Standardisation has not been adopted in any great measure with locomotives, but a recently introduced design of light-weight rolling stock is being specified generally for all new construction. Signalling equipment and methods are uniform throughout the system and most items of equipment such as are used on stations, goods yards, &c., are standardised.

The Swiss Federal Railway concentrates on the running and organisation of the system and makes extensive use of private industry. It does not concern itself with the manufacture of the equipment or rolling stock used on its lines. For instance, all locomotives, carriages and wagons are made by specialist firms to the requirements of the board, but all major overhauls and repairs to stock are carried out in the railway workshops. General construction work on the permanent way is carried out by private contractors, minor or urgent repair and maintenance work being done by the railway staff.

Fuel Research Report

The progress made in fuel research and details of the main programmes and the advisory work undertaken for 1952 are contained in the annual report of the Fuel Research Board, published last week. Mention is made of the need to avoid an unduly rapid depletion of the best coking coals for the production of metallurgical coke. Recent experiments have now shown that satisfactory metallurgical coke can be made from blends of a first-grade Durham coking coal with as much as 50 per cent of a weakly coking Northumberland coal. Dealing with the increased proportions of coal of small size and higher ash content which have arisen with the increased mechanisation in coal mining, the report refers to preliminary trials with an experimental "cyclone" generator to consume them. Combustible gas has been produced from coal below $\frac{1}{16}$in in size when gasified at high temperatures with air enriched with oxygen. Work on the synthesis of oil and chemicals from carbon monoxide and hydrogen made from coal and coke has now been extended by the design and construction of a pilot plant with the object of obtaining chemical engineering data. The report explains that in the present experiments the catalyst is kept in motion as a "fluidised solid" by the flow of the reacting gases. In connection with combustion research associated with the gas turbine, it is stated in the report that the "straight through" combustion chamber is now being developed to operate at a pressure of several atmospheres. Mention is also made of investigations of the efficiency of space heating systems and of domestic appliances. In addition to these items the report gives details of the work in hand on boiler availability and other industrial boiler problems, including the removal of sulphur compounds from flue gas, and also of the researches into the fundamentals of the chemistry and physics on which the various large-scale investigations are based, for example, coal constitution, surface chemistry, the use of radioactive tracers in a study of the Fischer-Tropsch synthesis. The report is published by Her Majesty's Stationery Office, price (by post) 2s. 7½d.

The British Instrument Industries Exhibition

No. I

THE British Instrument Industries Exhibition is being held in the National Hall, Olympia, London, from June 30th until July 11th. There are 170 exhibitors and the display of their products shows something of the thriving conditon of British instrument manufacturers and of the contribution they can make towards increasing industrial productivity. In round figures this industry itself has an annual production of more than £30,000,000 and nearly 40 per cent of this output is exported.

An indication of the scope and variety of the industry is given in the following description of some of the exhibits to be seen at Olympia.

Mullard, Ltd.

An interesting example of the application of electronic instruments to non-destructive testing is the ultrasonic concrete tester exhibited by Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2. This instrument is made by the company to a design evolved by the Road Research Laboratories of the Department of Scientific and Industrial Research. It provides a means of measuring the quality of concrete both in test samples in the laboratory and the actual structural member *in situ*. In both applications this test can be accomplished without any damage to the concrete under test. The instrument also facilitates non-destructive testing of concrete during the hardening process, thus avoiding waste of time in removing shuttering or releasing tension on the wires in the manufacture of prestressed concrete.

In the operation of the ultrasonic concrete tester, measurements are taken of the velocity of a pulse of ultrasonic energy as it passes through the concrete. The velocity is dependent upon the elastic modulus of the material, which in turn varies with the quality of the concrete. The test equipment consists of two transducers, coupled to the equipment by flexible leads,

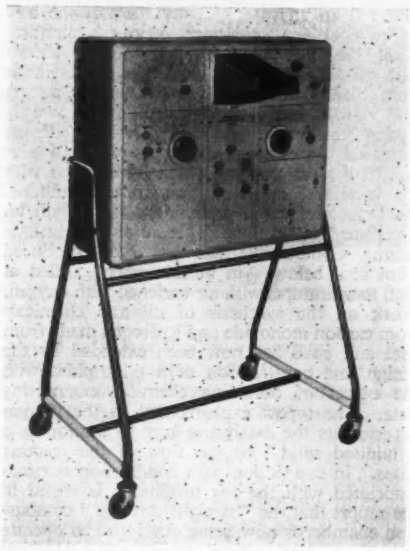


Fig. 1—Ultrasonic Concrete Tester—Mullard

which are held on opposite faces of the concrete under test. Into one, the transmitter, is fed a pulse which produces a short train of ultrasonic vibrations in the concrete. These vibrations are then picked up by the receiving transducer and, by means of electronic timing circuits and a cathode-ray tube display (Fig. 1), the time interval is measured and the velocity calculated. The equipment operates at a nominal ultrasonic frequency of 250 kc/s. The pulse repetition frequency is 50 per second. Testing can be carried out rapidly and a high order of accuracy can be attained to within $\pm 0 \cdot 2$ micro-seconds.

Until recently it has not been possible to use ultrasonic energy successfully in industrial processes (as distinct from testing) because the level of ultrasonic power that could be produced has been limited. During recent years, however, this limitation has been removed through the development of generators capable of delivering ultrasonic power of 1000W and upwards. Some interesting possibilities of high-power ultrasonics

Fig. 2—Ultrasonic Deep Tinning Bath—Mullard

in industry are illustrated by a range of equipments shown on the Mullard stand. These exhibits include ultrasonic tinning equipments, ultrasonic tools for drilling and machining hard materials, and magneto-striction and quartz-crystal generators.

Among this group of exhibits is the " E 7587 " ultrasonic soldering iron, which provides an effective means of soldering aluminium and other light metals without the use of flux. Its applications include the repair of unstressed light alloy castings and the rectification of surface defects, the repair and modification of aluminium foundry patterns, the soldering of connections to aluminium foil condensers, and the fabrication of intricate light metal assemblies, such as waveguides, X-ray casettes and marine fittings.

The soldering gun consists of a copper soldering bit and a magneto-striction transducer oprating at an ultrasonic frequency of approximately 22 kc/s. The driving power for the transducer is derived from a separate " E 7595 " power unit which takes its supply from a.c. mains. The soldering bit is heated by means of a conventional resistance winding. In the operation of the iron, the rapid vibration of the soldering bit disrupts the highly refractory oxide film which normally forms on such metals as aluminium. A clean surface is in this way obtained, enabling effective soldering to be carried out.

Three versions of ultrasonic tinning baths, suitable for tinning parts that cannot easily be handled by the soldering iron, are on show. They operate on the same working principle as the soldering iron. One of these equipments —the deep tinning bath, which is being shown for the first time at a commercial exhibition— has been designed primarily for tinning the ends of heavy aluminium cables to facilitate connection to the lugs. It is actuated by means of a magneto-striction transducer, of 1in cross section, to which is brazed a solder bath of $\frac{3}{4}$in diameter and approximately 2in deep (Fig. 2). The solder is kept molten by a conventional heating element. The instrument operates at an ultrasonic frequency of approximately 25 kc/s, and the ultrasonic power required is approximately 250W.

Another promising application of power ultrasonics is the drilling and machining of hard materials. Two instruments have recently been built at the Mullard research laboratories to investigate the drilling and machining mechanism facilitated by ultrasonic techniques. The first is an experimental ultrasonic reciprocating bench drill and the second a high-power reciprocating boring and milling machine. These instruments appear to offer increased scope for the machining of very hard and brittle materials such as tungsten carbide, magnetic ferrites, glass, ceramics, quartz and precious stones.

In the ultrasonic reciprocating bench drill exhibited, a high-Q magneto-striction transducer is used to generate vibrations at about 22 kc/s. These vibrations are transmitted via a tapered metal stub to a drilling tip. The tapered stub acts as a step-up velocity transformer. The amplitudes obtained are large enough to allow rapid drilling and cutting of most brittle materials when a slurry of carbide abrasive is fed to the tip. For example, using about 40W electrical drive power, a $\frac{1}{4}$in square hole can be drilled $\frac{1}{4}$in deep in about one minute in glass, ceramic and similar materials, using a carborundum abrasive. In tungsten carbide, using boron carbide abrasive, the corresponding drilling time is about ten minutes.

General Electric Company, Ltd.

A recently introduced miniature a.c. link testing ammeter is being exhibited by the General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. It consists, in effect, of a split core current transformer connected to a sensitive moving-coil rectifier instrument scaled in amperes. The complete instrument (Fig. 3) is mounted in a " Bakelite " case and the links

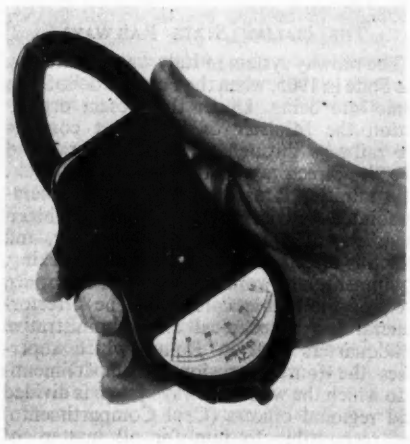


Fig. 3—Miniature A.C. Link Testing Ammeter—G.E.C.

are fully insulated for use on bare conductors up to 600V. The split-core current transformer consists of a pair of links, one fixed, the other hinged to enable the links to encircle the conductor under test. Three ranges (1A to 10A, 2·5A to 25A and 5A to 50A) are provided, the appropriate range being selected by a thumb-operated switch. The instrument measures 7in by 3in by $1\frac{1}{4}$in and weighs 1 lb 1 oz.

Unicam Instruments (Cambridge), Ltd.

A new double-beam infra-red recording spectrometer is one of the exhibits shown by Unicam Instruments (Cambridge), Ltd., Cambridge. This equipment is designed to suit two main applications—that of reliable double-beam operation in the rock-salt region for routine analytical work, for which a compact, robust and portable layout is indicated, and that of industrial or academic research in which versatility in spectral range, resolution and recording speed are required, and are made available by means of appropriate accessories.

Two design considerations have largely determined the form of the instrument : first, the use of an evacuated light path, which can lead to considerable improvements in speed and

precision in double-beam operation, but necessitates a somewhat unconventional mechanical design, and, secondly, the self-contained trolley mounting of the complete instrument. In the basic form of the instrument the evacuable monochromator and photometer units form the top, the front being occupied by the drum recorder and controls, which are readily accessible to a seated operator. A single monochromator of standard Littrow pattern (having an off-axis paraboloid of 35cm focal length as collimator and a prism of 7·5cm edge) is used. The slits are magnetically operated and programmed by means of an electrical cam, giving, if required, constant cm^{-1} resolution, and a wide range of chart and scanning speeds is available using control panel selectors. Double-beam operation is on the switching-in-time principle employing a calibrated diaphragm inserted into the reference beam by a servo-mechanism and linked to the recorder, which uses a 10in chart width on a drum 12in in diameter. A Golay cell is used as the radiation detector. Wave-number cams are used to operate the Littrow mirror, the frequency being indicated on a wave-number counter, and by chart markers operating at $10cm^{-1}$ intervals. The counter may be set manually at the beginning of each cam and switches are provided to give a quick return of the wave-number cam for repeat runs.

Provision has been made in the basic design of the instrument for the use of up to four prisms with automatic interchange, for the installation of a second monochromator using prisms or gratings, or for multiple-pass operation to improve resolution and minimise stray radiation. Space is available for the use of alternative radiation detectors, and c.r.t. presentation of spectra at cam repetition frequencies up to 100 c/s may be provided as an accessory. The double-beam photometer unit, which is in a vacuum housing independent of that of the monochromator may be replaced by a single-beam unit for such tasks as microscopy or reflection measurements. Automatic repeat scanning of portions of a given cam range will also be possible.

Crompton Parkinson, Ltd.

Improved designs of circular-scale electrical indicating instruments are exhibited by Crompton Parkinson, Ltd., Crompton House, Aldwych, W.C.2.

The 6in dial moving-coil voltmeter in a projecting pressed steel case (Fig. 4) has a long, open, circular scale and a tapered pointer to facilitate rapid and accurate readings.

In Fig. 5 we illustrate the movement of a

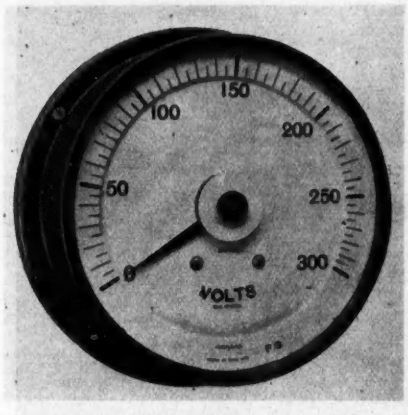


Fig. 4—Six-inch Dial Moving-Coil Voltmeter—Crompton Parkinson

circular-scale moving iron instrument. The magnet system is a self-shielding assembly consisting of a yoke, pole-piece, core and two anisotropic magnets. The yoke, pole-piece and core are of cadmium plated mild steel, and are rigidly located by being riveted between aluminium alloy plates which also hold in position the magnets which are located in slots in the yoke.

The moving iron movement is of the spring-controlled repulsion design with the addition of attraction elements forming part of the magnetic screens. These screens, besides incorporating the attraction elements and providing magnetic shielding against interference from external magnetic fields, also increase the efficiency of the movement by reducing the ampere turns required in the winding to produce full-scale deflection. The moving-part assemblies are mounted on hardened and polished carbon

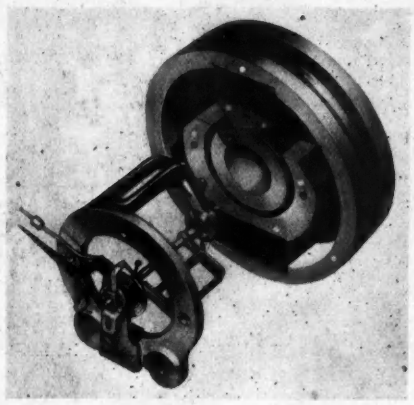


Fig. 5—Movement of Circular-scale Moving-iron Instrument—Crompton Parkinson

steel pivots working in synthetic sapphire jewel bearings which are spring-mounted to protect the pivots from damage due to vibration and shock. As illustrated in Fig. 4, the pointer is of tapered spear shape and moves in the same plane as the raised rim of a platform type dial, thus avoiding risk of parallax error when taking readings.

C. Baker of Holborn, Ltd.

The interference microscope exhibited by C. Baker of Holborn, Ltd., 244, High Holborn, London, W.C.1, marks an important development in microscopy. Both phase-contrast and interference microscopy provide intensity-contrasted images of phase-changing specimens by means of optical interference phenomena, but the important distinguishing characteristic of the latter method is that the mutually interfering beams which produce the contrast are generated by an interferometer system incorporated into the microscope, thus avoiding dependence upon diffraction by the object structure.

The instrument is essentially a normal Baker "Series 4" microscope, but is fitted with matched condenser and objective pairs whose optical systems exert a double-focus effect by virtue of the double-refracting plates incorporated in them. It is both simple to use and to adjust.

The double-focus action of the condenser illuminates axially separated planes of the specimen with the same portion of the luminous source, while the subsequent double-focus action of the objective brings these two separated planes into coincidence in the image plane, which plane consequently contains a correctly focused image of the specimen superimposed upon a mutually coherent out-of-focus image of the specimen. These images interfere in a manner which is controlled by means of a double-refracting phase-shifting system. This control permits the interference contrast to be varied between positive, central darkfield and negative contrast.

Three interference objectives, ×10, ×40 and ×100 (oil immersion) are at present being made.

An important application of the principle of the interference microscope is to the examination of surfaces for lack of flatness, an application which will prove of particular interest in the domain of high-precision engineering, for the assessment of surface finish.

A bi-refringent element in the microscope produces interference fringes in the eyepiece of the microscope, which are bent by lack of flatness in the object under examination. The spacing of the fringes is adjustable and their lack of straightness, and therefore any lack of flatness of the object, may be measured by a micrometer eyepiece.

A variety of normal microscope objectives may be used and various fields, and magnifications therefore, covered. The instrument is portable and may be placed on large work pieces which require examination. Alternatively, small work pieces may be placed on the microscope stage.

Electronic Instruments, Ltd.

The "Myria" megohm-meter (Fig. 6) exhibited by Electronic Instruments, Ltd., Richmond, Surrey, is a direct reading instrument which is of interest to the electrical engineer who is concerned with insulation testing or with the accurate measurement of resistance from 150,000 ohms to 200,000 megohms.

The instrument has two test voltages, 150V and 500V. It is a portable, mains-operated instrument housed in a metal case having a smooth grey finish. Resistance readings are given directly on the 6in moving-coil meter, as illustrated.

Below the meter is a ten-position range switch which carries two scales; switching on the left-hand scale applies a test voltage of 150V to the sample, while switching on the right-hand scale applies a test voltage of 500V. The scales are coloured green and red respectively and the meter carries two scales which bear corresponding colour indications.

There are three terminals labelled "High," "Low" and "Guard," and the instrument can

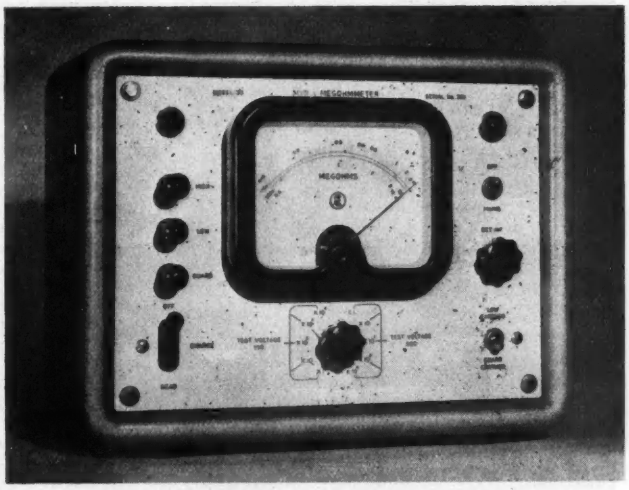


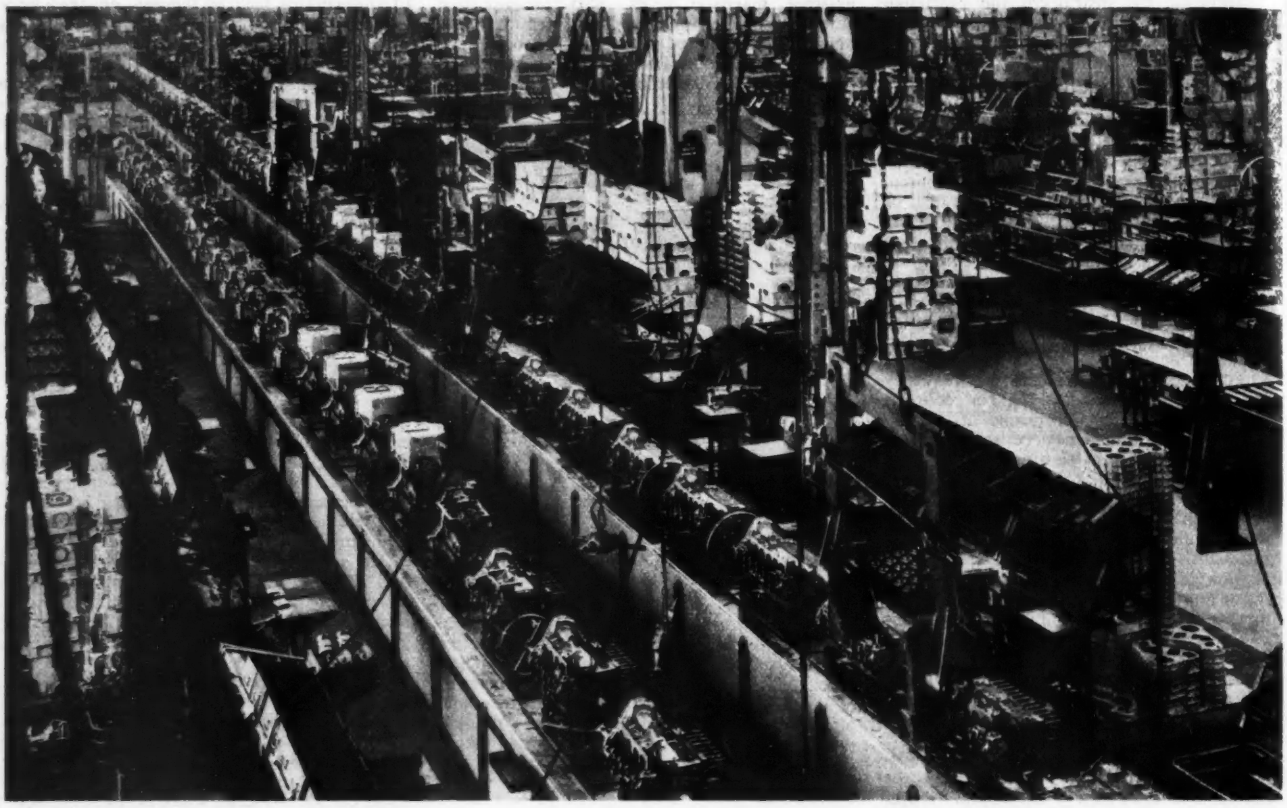
Fig. 6—"Myria" Megohm-meter—Electronic Instruments

be earthed through the third core of the mains lead. A spring-loaded lever key below the terminals applies the test voltage to the sample; releasing the key removes the test voltage from the terminals, and thus safeguards the operator. On the opposite side of the panel, a change-over switch enables either the "Low" terminal or the "Guard" terminal to be earthed. The instrument is suitable for a.c. mains of 110V to 120V and 200V to 250V at frequencies of 40 to 60 c/s.

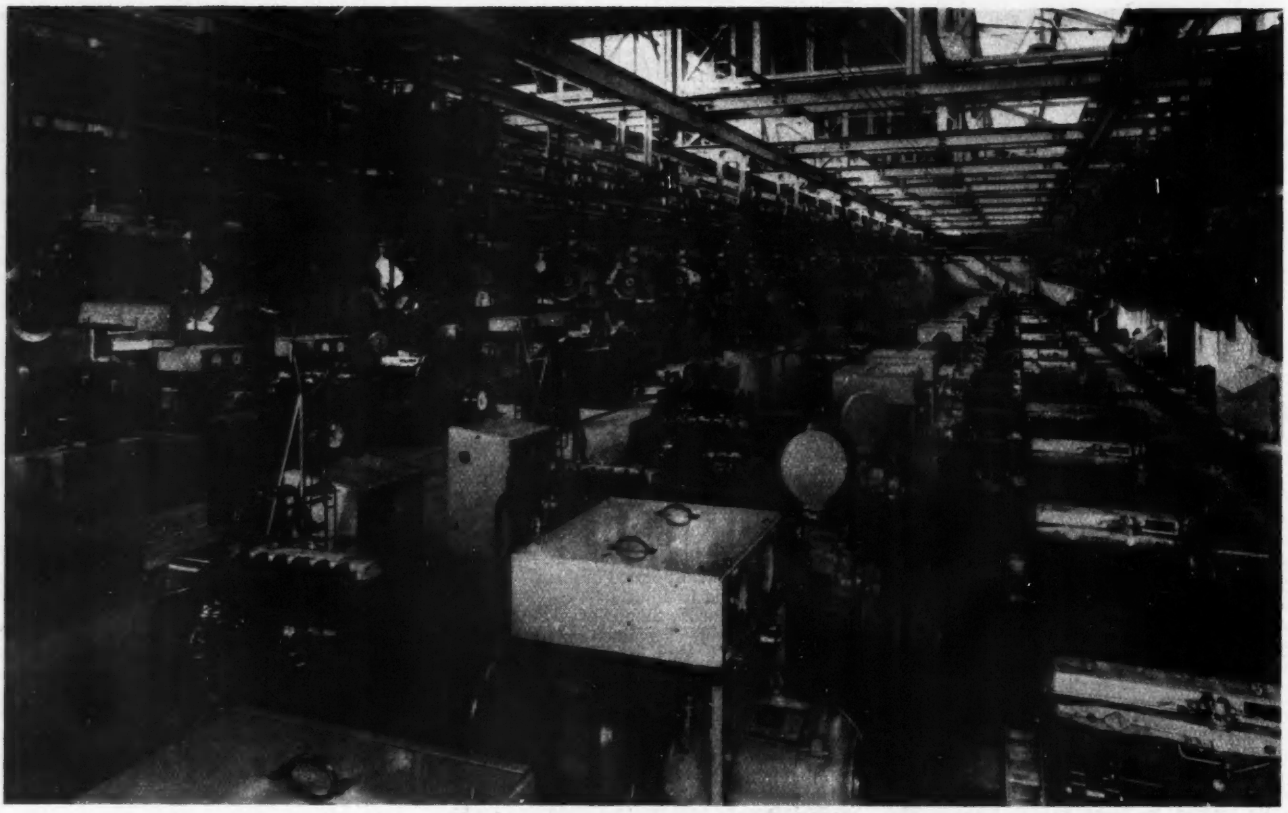
(To be continued)

The British Electricity Authority announces the appointment of Mr. F. S. Naylor, M.I.E.E., as specifications and contracts engineer in the chief engineer's department.

EXTENSIONS TO A DIESEL ENGINE WORKS



Engine Assembly Lines



Engine Test Shop

Extensions to a Diesel Engine Works

When in 1950 it became evident that the existing manufacturing capacity of its Eastfield works was insufficient to meet the increasing demands for diesel engines, F. Perkins, Ltd., of Peterborough, decided to double the factory area and reorganise its production lines. This work has now been completed, and it has not only made possible the doubling of the output of the well-known "P" series of engines, but also the production of two new models—the "L4" and the "R6."

A COMBINED extension and re-equipment scheme recently completed at the Eastfield works of F. Perkins, Ltd., Peterborough, has doubled the productive area of the factory, whilst its potential capacity has been quadrupled by the revision of the existing plant layout and the introduction of new equipment and methods. Under the scheme the output capacity for the firm's "P" series engines has been doubled and production started on the recently introduced "L" and "R" series.

The original main factory block was 600ft long by 200ft wide and consisted of ten 60ft wide bays. There were also two smaller buildings, each 200ft long by 60ft wide, which housed the electrical distribution centre, castings preparation department, a canteen, a stores and a maintenance section. This factory area was fronted by the main office building. The new extensions have increased the width of the main factory block on the east side by 245ft, an effective increase of 200ft, the balance of 45ft providing for a covered roadway through the centre between the two blocks.

The extension follows the general construction of the first block, having ten bays, 200ft long by 60ft wide, with a roof height of 40ft to the apex and 25ft to the eaves. The steelwork has been strengthened in the new block to carry a load of 4 tons per truss in order to allow the installation of overhead conveyors, &c., without additional floor supports.

Further extensions have been made to the ancillary buildings to accommodate the greater needs of the factory. The casting preparation block, where the major castings are cleaned before being passed to the machining lines, has been extended by 3500 square feet and a balcony floor of 4700 square feet added for the pipe manufacturing department and hardening shop.

The test shop, complete with power, water, fuel and exhaust services, is located at the southern extremity of the new block, where noise isolation and ventilation can be improved by making the whole of the south wall removable by means of sliding doors, which are opened for much of the year when the shop is in use. Ventilators have been fitted in the roof ridge to assist in the removal of hot air generated by the running of engines.

The arrangement of the building will permit future extensions to be made without dislocating the layout of the factory as a whole, by extending southwards. In order to avoid any loss in production whilst the scheme was being carried out the new equipment for increasing the output of the "P" series engines was installed in the new block, whilst the existing plant was transferred during week-ends and holidays. In this way the whole of the "P" series plant and the new equipment arranged for the revised production methods was transferred and installed in the new block without interfering with production. At the same time the space made available in the original block was laid out with plant for the production of the "L" and "R" series engines.

Wherever possible machines tooled up by suppliers were proved before being delivered, but where the machine and tooling were purchased separately the two items were set up and proved by the tool tryout section before handing over to production. By this method full sections were transferred, new machines and equipment introduced and the whole line made ready for production on the morning of the first working day after a week-end or holiday period. It is of interest to note that in the course of the scheme 380 machines have been moved to new positions, 450 new machines installed, 4000ft of roller track installed complete with turnover fixtures, &c., whilst air, power and electrical supplies and fittings have been incorporated.

The central roadway divides the factory into two main factory blocks, the original area now producing "P" series engines being known as Block 1 and the new area in which "L" and "R" engines are made being known as Block 2. Under the new layout the general flow of production is from the roadway down the production lines towards the outer walls along which the main engine assembly lines are arranged. All castings and materials purchased from outside are delivered along the central roadway and unloaded directly into stores and inspection stations at the head of the production lines set at right angles on each side of the road. After inspection the materials are passed directly to the head of the machining lines, from the end of which the finished parts pass straight on to sub-assembly lines and on to the assembly section. There are no stores between the machining and the sub-assembly lines and only a minimum buffer stock of assemblies is held at the end of the process lines feeding the main assembly lines. As far as possible the individual manufacturing lines are positioned in relation to the engine assembly line to coincide with the applicable assembly station. This method of delivering parts and sub-assemblies to the point in the main assembly line where they have to be built into the engines reduces the number of movements and transport to a minimum.

The potential production of engines from each building block is about equal. The ultimate planned capacity from Block 1 is some 150 engines per shift of the new "L4," "R6" and "S6" series, whilst in Block 2 a similar number of "P" series in three, four and six-cylinder models will be produced per shift. There are several sections within the factory which serve the needs of both of the blocks, and these sections are balanced to occupy an approximately equal area on each side of the central roadway. These sections include the lines of automatics, the jig and tool stores, the toolroom, a general-purpose machining section, engine finishing and despatch shop, test shop, &c.

The general-purpose machining section is engaged upon the production of special components, such as flywheels, housings, bearers, &c., for engines to suit them for special requirements. The standard engines are fitted with these components to suit them for a wide variety of applications in the finishing and despatch section of the factory. It will be appreciated that these two sections make it possible to adapt the engines for special purposes without interrupting in any way the main production flow on the specialised machine and main assembly lines.

In laying out the production lines full advantage has been taken of the opportunity to introduce methods and machine tools of the highest productive capacity and efficiency. An immediate result of introducing new production methods and layout has been shown in the manufacture of "P" series engines. In this section each engine produced requires 25 per cent less labour than hitherto, and a 50 per cent saving is anticipated when the plant is fully utilised.

A majority of the fixtures and tooling has been designed by the firm's own staff and pneumatically operated jigs and fixtures are widely used throughout the works, although in certain special cases hydraulically operated equipment has been adopted. The extensive use of dual loading and indexing fixtures and transfer machines reduces time loss in machine loading and operator fatigue to a minimum. Machines and fixtures have been designed as far as possible to maintain a common loading height and fixture loading is by direct sliding of the components. Gravity roller conveyors installed between successive machines are arranged to maintain the loading height and where it has proved impossible to maintain this height air-operated lifting tables have been installed. Turnover fixtures are used for transferring the heavier components from one face to another and any lifting necessary is done by pneumatic lifting cylinders. On the smaller component process lines extensive use is made of gravity chutes for feeding components through successive operations and on certain sections where machines are closely sited work tables perform the same function.

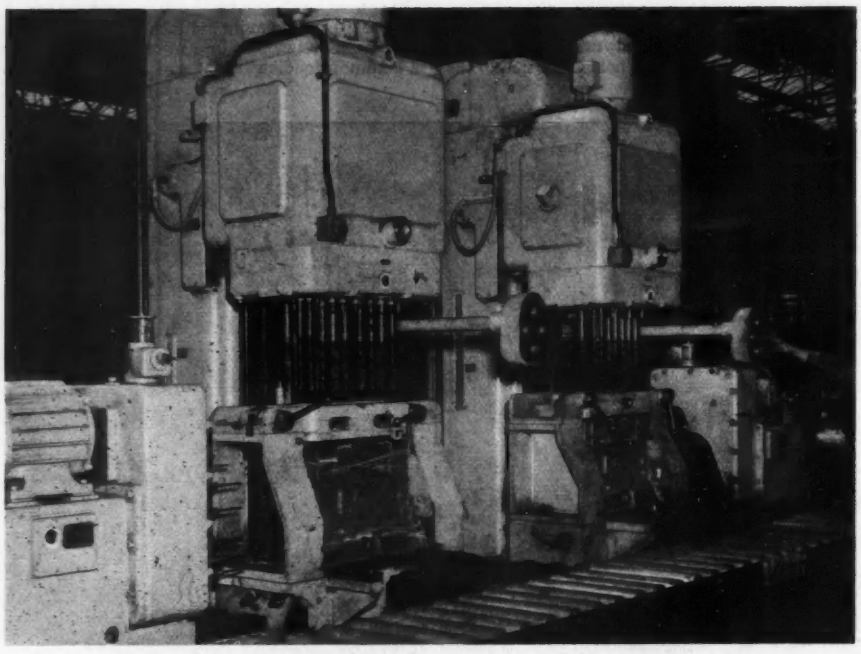
Six Station Automatic Transfer Machine

Many interesting transfer machines are installed and amongst them is the one illustrated on this page. It is one of a pair of Archdale six-station machines, which, together complete all the boring, drilling and reaming operations on the "L4" engine cylinder head. With these machines a complete head is produced every 114 seconds, and in them some 164 tools are in operation simultaneously on a group of heads.

The three-cylinder and four-cylinder blocks for the "P3" and "P4" engines are produced

in batches in one machine section, and to provide for the different dimensions of the blocks some interesting machine layouts and duplex tooling arrangements have been introduced. These arrangements not only reduce the amount of floor space required, but enable several of the machines to be changed over with a minimum loss of time from one cylinder design to the other. For certain of the operations where the tooling on one machine cannot quickly be adapted to suit each cylinder block the feed conveyor is fitted with a switch point. By setting this point the blocks are directed to one or the other of two or more machines tooled up for the particular operation on three or four-cylinder blocks. As they leave these machines the diverted blocks are re-directed to the main run of roller conveyor for subsequent operations on machines with common tooling.

A further example of space saving and adaptation of a single machine unit for the two kinds of blocks is shown in the photograph on this page. The holes at the front and rear ends of the three and four-cylinder blocks are common to both sizes, but those on the top faces are naturally different. The two two-way multi-drill head machines shown have been tooled up to drill the three faces in both types of cylinder blocks. Each is fitted with a fixture quickly adaptable to take either size of block, but the vertical multi-drill head of one is tooled for the three-cylinder block whilst that of the other drills the four-cylinder block. In the first machine the head face of the " P4 " block and the front ends of both " P3 " and " P4 " blocks are drilled. From it the " P4 " blocks pass to the second machine, where only the rear ends are drilled. If " P3 " blocks are passing through only the front end is drilled in the first machine and the head faces and rear ends are drilled in the second machine.



Cylinder Block Multi-drilling Machine

Another example of making the best use of modern methods to speed work and save floor space is in the section concerned with the making of connecting-rods and main bearing caps. Here three vertical broaching machines are used on the production of " P " series connecting-rods, and they occupy a floor space of about 300 square feet. To perform the same operations at a comparable rate by the old methods it would have been necessary to install fifteen milling and multi-spindle drilling machines taking up a floor space of some 1000 square feet.

As already mentioned, sub-assembly work is only a continuation of the machining lines, finished units supplied by outside contractors being delivered from the central stores through the machine lines to the required points without further processing. Typical of the main assembly lines is that for the " P " series engines illustrated on page 22. The engines are assembled on pallet conveyors, on which they are carried past successive sub-assembly stations at the ends of the machine lines. At the required points along the lines an engine in process of assembly can be raised on a special rig by an overhead block unit and turned as necessary without effort on the part of the assemblers. Power-operated tools are used wherever possible in assembly and any need for selective assembly is eliminated by the close observance of tolerances in the preceding machinery operations.

At the end of the assembly lines the engines are picked up by an overhead conveyor system and the pallets are taken back to the head of the assembly section by an automatic return system. The overhead conveyors from each of the main assembly lines converge and carry the engines to the test shop. This conveyor system is designed to maintain a buffer stock of engines between the assembly and test departments.

In the test shop, shown in another of our illustrations, the test beds are arranged down each side and the overhead conveyor bringing the engines in runs round the outside walls. The engines can be moved off the main conveyor system on to short lengths of overhead parking rail by each bed. An overhead traverser which runs along the full length of each series of test beds is used to remove the engines as required from the parking rails and to set them on the test beds. The kind of test brake mainly in use is of the firm's own design and is based upon a motor generator forming a load resistance against which the engine is run. The power generated is fed back into the mains for use in the factory. The beds are arranged in pairs to economise in floor space, there being twenty-five units installed. Other test beds in use are equipped with dynamatic dynamometers and water brakes, and all of the testing equipment is designed as far as possible to handle any type of engine.

After testing the engines are removed from the beds by the traverser and placed on an overhead conveyor, which takes them to the finishing line. On this line special parts for particular applications are fitted before the engines are spray painted ready for storage and subsequent despatch.

Particular attention has been paid to ensure good working conditions in this factory. It is heated throughout by means of electrically operated gas heaters arranged along the central roadway. These heaters draw in cold air through pipes heated by gas burners, the heated air being circulated by fans through the factory by means of overhead ducting. In summer the process is used without the gas heaters and cold air is circulated throughout the same ducting. For operator comfort, safety, noise absorption and wear resistance the main floor in the new block has been constructed of wood blocks.

The factory has excellent natural lighting and the artificial lighting throughout is by high-pressure vapour mercury lamps wired alternately in the three-phase circuit to prevent the stroboscopic effect obtained when a single-phase wiring is used. Also interspersed in the lighting are a number of normal tungsten lamps, which give instantaneous light in an emergency and also correction to the mercury type to simulate daylight as near as possible.

Power feed to the machines and equipment is by means of an overhead busbar system, which allows complete flexibility of movement and a rapid means of supply connection when installing or rearranging plant.

An Improved Control Chart

PARTICULARS have been received of some recently introduced improvements to facilitate and widen the uses of the " Graphdex " production control system distributed by Remington Rand, Ltd., 1, New Oxford Street, London, W.C.1. This system, developed by Mr. W. Gray Horton, has been used in industry for some time and is based essentially upon slotted boards into the slots of which are fitted coloured signals of different shapes and sizes. These signals can be keyed to any particular operation or function it is required to record.

In the improved equipment the main components still consist of a unit slotted board and plastic signals in a variety of colours, shapes and sizes which fit the slots. Now, however, an uninterrupted metal charting surface can be produced which can be enlarged to any size; and in the case of such applications as time charts it is now possible to remove portions of the chart which become obsolete and slide forwards the still current portions to take their place. By thus making room to add further charting fields, an everlasting forward picture of events can be presented. With a new long strip signal on a metal backing plate it is now possible to construct and strip bar or compound bar charts much more quickly than before.

Technical Reports

Design and Performance of a Portable A.C. Discharge Detector (Ref. V/T115). By G. Mole, Ph.D., F.Inst.P. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 15s., postage 3d.—An account is given of the considerations entering into the design of a.c. discharge detectors, but much of the information is also applicable to the design of amplifiers for d.c. discharge detectors. The particular equipment described was constructed for making tests in the field on the major insulation of electric power systems.

Flameproof Electrical Apparatus : Flanged Joints, One Half-inch in Radial Breadth, in Mixtures of Ethyl Ether Vapour and Air (Ref. G/T277). By H. Robinson, J. T. W. Roper and N. Simpson. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s. 6d., postage 3d.—For explosive mixtures of ethyl ether vapour and air, ignited in a bronze sphere having horizontal equatorial flanges one half-inch in radial breadth, the most incendive is that containing 4 per cent of ether vapour by volume. The most readily ignitable external mixture contains 3·6 per cent of ether vapour by volume. For this combination of internal and external mixtures, the maximum experimental safe gap, on a criterion of $n=20$, $k=0{\cdot}001$in, is 0·029in, and the statistical maximum safe gap, calculated by the improved method recently adopted is 0·020in. The effect of reducing the flange breadth from 1in to one half-inch cannot yet be assessed, since the data relating to 1in flanges, contained in Ref. G/T109, were determined by methods which differed significantly from those described in this report. A redetermination of the safe gaps for 1in flanges is planned in order to permit the quantitative effect of the reduction in flange breadth to be ascertained. The tests were made at Buxton in co-operation with the S.M.R. Establishment of the Ministry of Fuel and Power.

Combined Electricity and Heat Supplies*

By H. S. PROSSER, B.Sc., A.M.I.Mech.E., A.M.I.E.E.† and A. W. PEDDER, B.Sc., M.I.Mech.E., M.I.E.E.‡

No. II—(*Concluded from page 903, June 26th*)

This paper seeks to establish, so far as is possible with the widely different circumstances which arise in practice, what fuel savings are likely to be effected in the various fields of application of heat-electric generation and what will be the financial effect. From this viewpoint the domestic, commercial and industrial loads are analysed and the supply of steam to a group of factories from a central heat-electric station is considered. The following abstracts are from the third part of the paper and are concerned with industrial supplies.

Industrial Supplies

THE wide differences between factories in magnitude of the total requirements, the steam pressure required for factory processes and the ratio of electricity to heat load, make generalised treatment of the economics of industrial heat-electric generation complicated to the point of being almost impossible. It is proposed, however, to make the attempt and to draw some general conclusions from a study of a very limited number of alternative cases, summarised as follows : maximum steam demands, 25,000 lb per hour and 100,000 lb per hour ; alternative process steam pressures, 90 lb, 45 lb, 15 lb per square inch g.; alternative steam load factors (ratio of annual average to maximum demand), 80, 60, 40 per cent.

The initial steam conditions are at the choice of the designer and to bring out the economics of this factor we have introduced three alternatives, 300 lb, 600 lb, 900 lb per square inch g.

In each of these cases only generation in back-pressure turbo-generator sets is considered. In rare circumstances pass-out condensing sets might also be justified and, in addition, oil engines with heat recovery plant can fill a useful though limited role.

Capital Cost of Generating Plant

It is obvious that even without electricity generation, boiler plant capable of meeting the peak steam requirements is necessary and that the usual ancillaries, such as coal-handling plant, steam and feed piping, are essential. In most cases the boilers can be of the shell type (Lancashire or Economic), which, with modern stokers, can give quite good performance at relatively low first cost.

To enable generation of electricity to be carried out higher pressure boilers of the water-tube type would be required together with more elaborate water treatment plant, deaerating plant and the more expensive equipment associated with higher steam pressures. One or more turbo-alternators will also be necessary, together with switchgear and cabling.

The capital cost of the plant and buildings required for the various alternatives set out above has been estimated and compared with the estimated cost of providing the steam by direct generation in shell boilers. The increased capital cost of heat-electric generation, as compared with steam production only, is shown in Fig. 3.

It will be seen that the size of installation has a very pronounced effect and that for a total steam load of 25 klb/hr. the additional costs incurred per kilowatt are nearly twice as high as for 100 klb/hr. This is partly due to increasing costs per kilowatt as unit sizes decrease and partly due to falling turbine efficiency with smaller machines, which results in fewer kilowatts being generated for a given boiler installation.

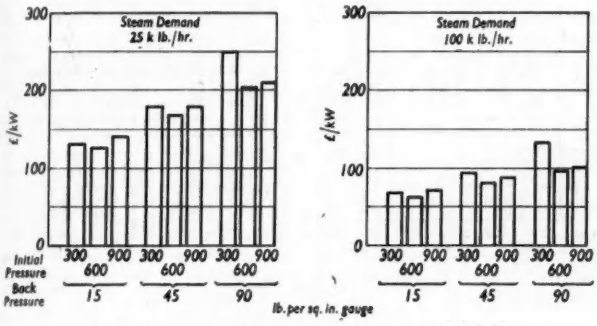


Fig. 3—Approx. Additional Capital Cost of Generation

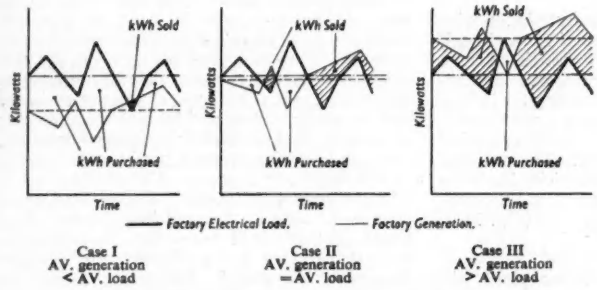


Fig. 4—Effect of Fluctuating Steam and Electrical Loads

Value of Electrical Output

The electricity produced by back-pressure generation is, in general terms, worth to the factory the price which would otherwise be paid to the Area Electricity Board for the supply. Normally the factory will be taking this Area Board supply on the basis of a two-part tariff and the value of the electricity produced can also be regarded as comprising a fixed and running component.

(i) *Fixed Component.*—For the kilowatt output of the back-pressure turbines to be worth the full value of the Area Board kilowatt charge, it would have to be available at all times when there is a demand by the factory for that quantity of electricity. In practice, however, there is seldom much correlation between the fluctuations of the steam and electricity requirements so that the full kilowatt output of the back-pressure set will not always be available when required, resulting in the balance of kilowatts having to be taken from the Area Board. There will also be occasions when the turbo-alternator is out of commission due to breakdown or for maintenance, the process steam then being taken through a reducing valve provided for this purpose. At such times a demand equal to the full kilowatt output of the set will have to be met from the Area Board supply.

The effect of fluctuating loads and outages will vary from factory to factory, depending both on the load factor of the steam supply and the nature of the processes carried out. A great deal will depend also on what characterises the annual load factor. For example, a load factor of only, say, 25 per cent might result from one-shift working with very steady loads or three-shift working with widely fluctuating loads.

Consideration of a number of typical cases leads us to suggest that in no case would the effective reduction in kilowatt charges paid to the Area Board vary much from about 60 per cent of the kilowatts installed. Since, moreover, the kilowatt value is a relatively small component in the economic balance, the adoption for all cases of a single figure of 60 per cent as the proportion of installed generating plant which can be regarded as firm should not invalidate any general conclusions.

Assuming the fixed component of the Area Board tariff to be equivalent to £5 10s. per kilowatt per annum, the gross annual value of the kilowatts produced, after making this reduction for non-availability, will be £3·3 per kilowatt installed.

The additional plant installed for the purpose of heat-electric generation will incur additional fixed operating costs and this must be deducted from the gross kilowatt value given above in order to arrive at the net value. The amount of this fixed cost will depend more largely on the maximum steaming capacity than on the kilowatt output, and we have allowed £2000 and £5000 per annum for the 25 klb/hr and the 100 lb/hr schemes respectively.

(ii) *Running Component.*—The running component of the Area Board tariff, with coal at 70s. per ton and 11,000 B.Th.U. per pound calorific value, would be about 0·8d./kWh. Hence, each unit generated by the back-pressure set will reduce the factory's electricity bill by this amount, and it remains to determine the cost to the factory of generating each unit in order to establish the net value of the unit output.

With heat-electric generation there is no loss of latent heat to the cooling water, as is the case in condensing stations, but coal still has to be burnt to provide the basic 3413 B.Th.U. per kWh plus an amount to allow for boiler losses and for turbine and generator radiation and

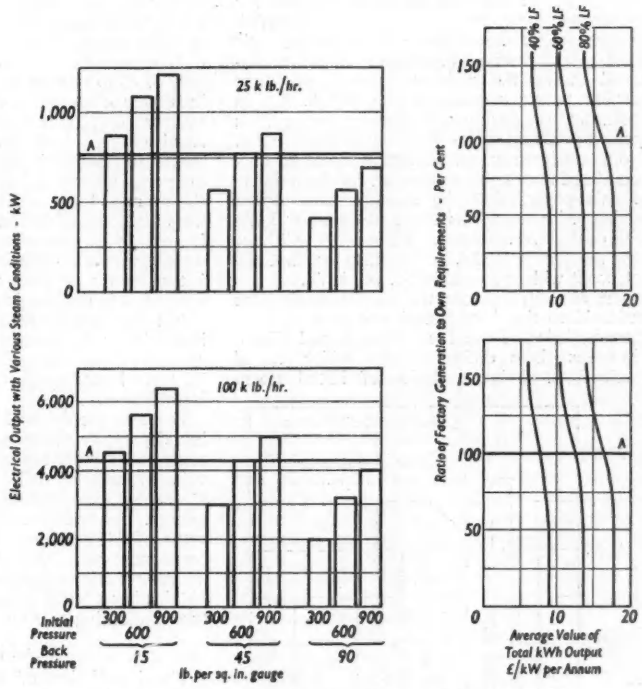


Fig. 5—Electrical Output and Value of kWh

* Paper, British Electrical Power Convention, Torquay, June 10, 1953.

† British Electricity Authority.

‡ Merz and McLellan.

mechanical losses. Assuming a boiler-house efficiency of 70 per cent and a turbo-generator external efficiency of 92·5 per cent, the efficiency of heat use will be 64·8 per cent, giving a heat consumption of 5260 B.Th.U. per kWh. The corresponding consumption of coal is 0·48 lb per kWh, giving a fuel cost of 0·18d. per kWh. The heat-electric plant will involve higher operating and maintenance costs (apart from the fixed component dealt with above) than will direct steam production, and this is estimated at approximately 0·02d. per kWh. Each unit generated in the factory will therefore cost 0·2d. and its value to the factory will be the difference between this figure and 0·8d., i.e. about 0·6d. per kWh.

The above calculation of the value of the units produced assumes that at all times the total electrical requirements of the factory are greater than what is produced from back-pressure generation, but it is necessary to consider the case in which the electricity produced exceeds what can be absorbed in the factory.

At such times the factory will have units available for sale to the Area Board, and the price which the Board, who is itself a retailer of electricity, can pay for these units must for obvious reasons be less than that which it charges to its consumers. Furthermore, their value will depend upon whether they are produced during the night when only the most efficient power stations of the B.E.A. are in operation, or during the daytime, when it is necessary also to run the less efficient plant. From consideration of all factors involved it is considered reasonable to assume, for the purpose of this paper, that the average Area Board buying price would be about 0·45d. per kWh with coal at 70s. per ton. These units will have cost the factory 0·2d. to produce so that the net profit will be about 0·25d. per kWh.

The relation between the units bought from and sold to the Area Board will vary with the characteristics of the factory load, and Fig. 4 illustrates three different cases which would result from different choice of initial steam

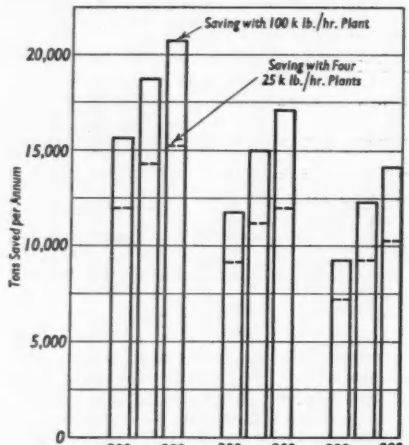


Fig. 6—Coal Saving per 100klb per hour of Steam Demand at 80 per cent Load Factor

pressure. In Case 1 the average local generation is well below the average factory load, but on one occasion in the period depicted there happens to be an excess to be sold to the Area Board. In Case 2, where average generation equals the average load, the number of kilowatt hours sold to the Area Board has increased considerably, although all of it is bought back at some other time. In Case 3 average local generation exceeds the load, with a corresponding increase in the average export to the Area Board. However, even in this case the factory occasionally buys units. The net effect is that the value of kilowatt hours generated does not suddenly drop from 0·60d. per kWh to 0·25d. per kWh at the point when average generation surpasses average needs, but there is a gradual transition from the higher to the lower value. This transition begins at the point where maximum generation sometimes exceeds requirements and ends where minimum generation always exceeds requirements In cases where there is a wide fluctuation of steam and electricity consumption the transition will occupy a correspondingly wide range.

Comparison of Costs with Net Value of Electricity

The amounts of electricity produced from the various schemes whose capital costs are given earlier differ widely, as shown in Fig. 5, and, as just explained, the kilowatt-hours output has a different value depending on whether, in total, it exceeds or falls short of the factory's own requirements.

To illustrate this point a line *A—A* has been added to Fig. 5 to represent the factory's average electrical load. It must be emphasised that in practice the line *A—A* might come almost anywhere on the vertical scale ; in the position in which it has been drawn in the diagram it assumes that a factory generating at 600 lb per square inch with a back pressure of 45 lb per square inch gauge could on average generate its own requirements. On the right-hand side of the diagram a graph of the average value of all kilowatt hours produced is given, drawn to such a scale, vertically, that it is true for the particular line *A—A* drawn in. From this can be read immediately the average annual value of the kilowatt hours output for any of the various installations.

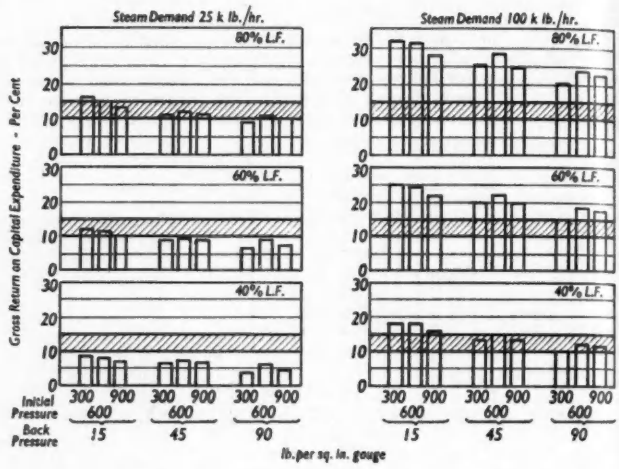


Fig. 7—Financial Return with Back Pressure Generation in Factories

For example, in the 25 klb/hr installation with initial pressure 600 lb per square inch and back pressure 15 lb per square inch gauge the average value of the kilowatt hours per kilowatt installed at 80 per cent steam load factor is £15 per annum. In addition the kilowatt output has a value of £3·3 per annum less a fixed operating component of £2000 per annum. The resulting net saving due to generating electricity has been obtained as a result of additional capital expenditure amounting to £126 per kilowatt (Fig. 3).

Coal Saving

The installation of back-pressure plant will effect a saving in the national coal consumption in two ways.

First, there will be a saving due to the improved efficiency at which the process steam itself is produced, resulting from the installation of more efficient boilers. This saving will be of direct value to the factory financially as well as decreasing the national fuel consumption. The estimated coal saving and its value at a steam load factor of 80 per cent are given below. There will, of course, be an approximately *pro rata* reduction for other load factors.

Size of installation	Annual saving tons	Annual saving £
25 klb/hr.	720	2,500
100 klb/hr.	4000	14,000

Secondly, there will be a saving in the national coal consumption due to the electricity generated by the back-pressure plant having been produced at a thermal efficiency of some 65 per cent. If this had been produced in a modern large condensing station the efficiency of production would have been about 27 per cent, which would have been reduced to about 24 per cent by losses in distribution and transmission from the power station to the factory. The coal savings resulting from this cause vary very widely with sizes, pressures and load factors. Fig. 6 gives an estimate of the total national coal savings for the range of alternatives considered.

Economic Advantage to Factory

In Fig. 7 the total value to the factory of generating electricity, i.e. the sum of the net value of the electrical output itself and of the saving in coal used to provide process steam, is shown as a gross percentage return on the additional capital expenditure. As made clear earlier, the main calculation is based on an assumed ratio of factory generation to factory electrical load (the line *A—A* on Fig. 5). In fact, there is very little difference in the figures if the line *A—A* is put still higher, but lowering it, i.e. assuming that the factory can absorb less of its own generation, soon begins to have a substantial effect. In the extreme case, if the factory has a negligible electrical load and hence must sell all its output, the gross percentage returns indicated on Fig. 7 would be reduced to about half or rather more.

In the case of a non-profit-making public body it would be considered adequate if this return on additional capital expenditure were equal to the additional capital charges incurred, together with their appropriate proportion of overhead charges, in total a figure of some 8 per cent. In the case of industry, however, money cannot normally be borrowed at such low rates of interest as in the case of public bodies, and loan repayments over a shorter period are usually considered desirable, while, as a trading concern, a reasonable margin is also required for profit. Different boards of directors may have widely varying views as to what gross percentage would justify them taking action, but it would seem that a return of at least 10 per cent and preferably not less than 15 per cent is essential. Accordingly a band has been shown on the diagrams with the minimum at 10 per cent and the maximum at 15 per cent.

The conclusions which it seems reasonable to draw from Figs. 6, and 7 are as follows :—

(1) The total size of the installation has a very pronounced effect on the results, an increase of four times in size almost doubling the gross return.

(2) The load factor of the steam requirements also has a great effect on the figures.

(3) The lower the pressure at which the process steam is used the more favourable is the case for back-pressure generation, owing to the increased kilowatt hours generated per pound of steam.

(4) Generally speaking, with the 25 klb/hr. installation the case for generation is marginal at 80 per cent steam load factor, and it is definitely not profitable if the load factor is as low as 40 per cent, a figure which, it must be emphasised, very many factories do not even reach. With the larger 100 klb/hr. installation generation is reasonably worth while, even at 40 per cent steam load factor, and becomes highly profitable at 80 per cent load factor.

(5) The percentage return does not change rapidly with increasing initial steam pressure and in none of the cases considered is there any advantage in going as high as 900 lb per square inch. The higher initial conditions do, however, tend to become more attractive as the back pressure rises.

(6) The overall coal saving, without going beyond the economically preferable medium pressures, is very considerable, varying from

some 10,000 tons to 17,000 tons per annum per 100 klb/hr. of steam demand at 80 per cent load factor.

The variables involved in heat-electric generation for factories are more numerous than for domestic and commercial premises and each case must ultimately be considered on its merits. It is believed that well over half the factories in the country have an annual coal consumption of less than 5000 tons, which is itself only about half the consumption with the smallest scheme considered in this paper, viz. 25 klb/hr. maximum steam demand with a load factor of 40 per cent. Nevertheless there is still a wide field in which back-pressure generation can not only lead to larger coal savings than seem likely to be achieved by associating this form of generation with either domestic or commercial heating; but, given a sufficiently favourable combination of size, steam load factor and electrical consumption, can be a profitable venture for the industrialist.

Finally, a reminder must be given that the coal price has been taken as being the same (70s. per ton) for the factories and for the B.E.A. In fact, many factories have to pay rather more than the average cost to their Area Board, while some, especially those with river frontages and jetties, may actually pay less.

Centralised Heat-Electric Generation

It will now be considered whether the profitability can be increased or the unprofitable cases made profitable by moving the location of the power-house to a point where it can serve several factories simultaneously.

Existing boiler plant in a B.E.A. power station could not be used for this purpose, as there could be no guarantee that surplus steam would always be available when required and, unlike hot water, the cost of storing steam is likely to be prohibitive. The centralised station could, however, take the form of an extension for the purpose of a nearby B.E.A. station without altering the following analysis.

The combination of a number of small power-houses into one larger one introduces a number of factors which lead to a great increase in the amount of permutation necessary to give a complete picture. For example, the number of factories served by the combined supply would have an important effect, their individual load factors would vary and it would be unlikely for them all to require process steam at the same pressure. Notwithstanding these complications, it may, however, be of value to calculate the costs applying to a centralised station on the following assumptions :—

(1) Supply is given to four factories, each requiring 25 klb/hr.

(2) Three alternative steam load factors are calculated, 80, 60 and 40 per cent, it being assumed that all four factories have the same load factor and that the diversity factor is 1·1.

(3) Three alternative back pressures are calculated, 90 lb, 45 lb and 15 lb per square inch gauge, it being assumed that all four factories require the same pressure.

The problem is to determine whether back-pressure generation in a station of this sort would be more or less attractive than generation in the four individual factories particularly with the national point of view in mind.

The capital cost, both per kilowatt of generating plant and absolutely, is considerably smaller; in fact, the centralised station is very similar in size and design to the factory power station for 100 klb/hr. Counterbalancing this saving in capital cost is a substantial extra for the cost of providing the steam transmission system from the power station to the four factories. Very wide variations are possible in this item, but for the size of installation being considered it is thought that there would be a probable minimum of £100,000 with an average nearer £200,000 to be spent on the steam distribution and condensate return system. The efficiency of generation would be considerably improved due to the fourfold increase in turbine size and the boiler efficiency would also be somewhat better. In these respects also the centralised station would be very similar to the larger factory power station previously considered.

As to the ownership and operation of the power station, we assume that it would not be by the factories themselves, either individually or in association. This is consistent with the idea that one of the main reasons for the centralised station is to relieve the factories of the need for raising capital. We assume, therefore, that the owner and operator would be the B.E.A. and that the electricity produced would be fed into the B.E.A. system and treated on a footing with generation from any of its other power stations. On this basis the value of the electricity produced is equal to the amount which the B.E.A. would have to spend to generate the same output in one of its latest power stations. As before, we take this as £6·3 per firm kilowatt S.O. per annum and 0·45d. per kWh S.O.

As with generation in the factories themselves the value of the kilowatts installed is reduced by outages due to breakdown or maintenance and also by fluctuations in the factories' steam loads. The steam and electrical diversities will, however, mitigate the loss of "firmness" in the electrical output and it is considered reasonable to take kilowatt credit for 70 per cent of the installed capacity, as compared with 60 per cent taken for individual factories. As regards the unit output there is in this case no change in value as the output increases, all units being worth 0·45d.

Fig. 8 shows the results of calculations made on this basis and is comparable with Fig. 7,

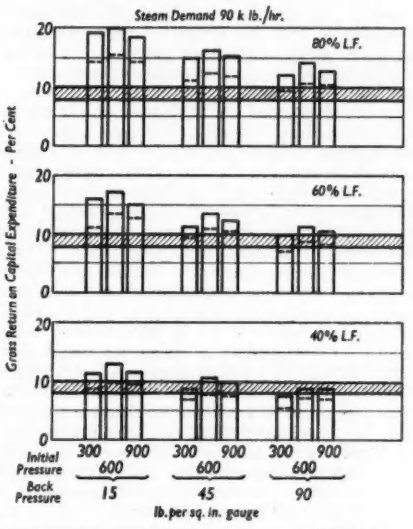


Fig. 8—Financial Return with Centralised Industrial Heat-Electric Supplies

which gives the same information for generation in the factory. In this case, however, the cross-hatched band representing the amount of the gross return which will be absorbed by capital charges can reasonably be placed rather lower on the assumption already mentioned that the B.E.A. would be able to borrow money at rather more favourable rates, that it will be prepared to depreciate the assets over a longer life and since it is a non-profit-making body. Between 8 and 10 per cent would appear to be adequate.

Comparisons of Figs. 7 and 8 shows that there is surprisingly little improvement when steam and electricity generation are centralised in this way. What has happened is that the very substantial savings due to lower capital expenditure and lower annual charges, plus the savings due to improved efficiency, have been more or less balanced by the extra cost due to steam transmission and to the fact that the electrical output is not worth as much to the B.E.A.—a wholesaler—as in the alternative case it was to the factory owner—a retail consumer.

The economics of any centralised scheme of heat-electric generation are inevitably greatly influenced by the cost of distribution but the above example shows that where this can be limited to reasonable proportions the result is comparable to heat-electric generation by the individual factories. Probably the greatest attraction of group schemes is that they present a means of obtaining for the nation the benefit of the fuel economy associated with heat-electric generation in cases where the individual factories would not install back-pressure generating plant because of the difficulty of raising capital.

Cost of Heat from Centralised Schemes

As far as the factory owners are concerned, their first reaction to proposals to have a centralised station would be to ask the price at which steam would be sold to them. Before leaving the subject we must therefore look at the figures from this point of view.

In the results presented in Fig. 3 it was simpler and clearer to exclude the basic cost of producing process steam and as these costs were also excluded from the study of the centralised station, Fig. 4, the results were strictly comparable. An approach to the full costs has, however, been calculated on the following basis:—

(*a*) Steam is produced in the factories in shell-type boilers with a nominal working pressure of 100 lb per square inch.

(*b*) In the centralised station the cost of steam is determined as the total cost less the value of the electricity to the B.E.A.

(*c*) The figures should not be regarded as absolute totals, because certain items have been omitted from both sides of the comparison, e.g., overheads and the cost of obtaining and treating make-up water, &c. Nevertheless, they are believed to be comparable.

A Die Casting Works Extension

We were recently able to visit the newly completed extension to the die casting factory of the Non-Ferrous Die Casting Company, Ltd., at Cricklewood. This firm was originally established in some old stables at Tottenham in 1923, where its production depended on the output of five small gas-fired furnaces. In 1927 the company moved to a single-storey building on its present site of 20,224 square feet and worked with eighteen gas-fired furnaces made to the company's specification, which, working in copper base alloy, had each a 900 lb capacity. It was then engaged only on gravity die casting in copper base and aluminium alloys. The foundry itself occupied about half this building, whilst the mechanical fettling shop and the tool shop where the die blocks are fabricated ran side by side in the remainder. The next reorganisation took place in 1937, when this building was extended breadthwise, the additional floor area being 11,600 square feet. The fettling shop was removed to this building, which also served to increase the available foundry area, the furnaces then numbering twenty-six.

The modern steel and brick wall structure which forms the present extension has also enabled an improved production layout to be arranged, the production capacity itself having been nearly doubled. It is a double-storey building covering 9000 square feet, and housing on the ground floor the inspection and despatch departments, the mechanical fettling tools, the maintenance room, canteen and administration offices. By the removal of certain inter-walls the whole of the existing floor space, with the exception of the tool room, has been made available for actual casting operations.

Provision has been made for forty-eight furnaces suitable for the gravity casting of non-ferrous alloys, and for six low-pressure die casting furnaces. These work at a metal pressure of 8/10 lb per square inch and are used almost entirely for aluminium work. When working to full capacity the plant is expected to have a monthly output of 100 tons copper base alloys, of which three-quarters will be brass, and about 30 tons of aluminium castings. The largest casting the company has produced weighed 15 lb, the average weight being 3½ lb, and last year over 4,500,000 castings were made.

A brass recovery plant is installed from which about 30 per cent of the weight of the furnace slag is recovered as brass. The simple principle of the process was originally conceived by the company and the machine is made by Sturtevant Engineering Co., Ltd. The slag is passed between rollers, an action which flattens the brass particles and so increases their surface areas that after passing the rollers they are retained on sieves which pass the ash and oxides as dust.

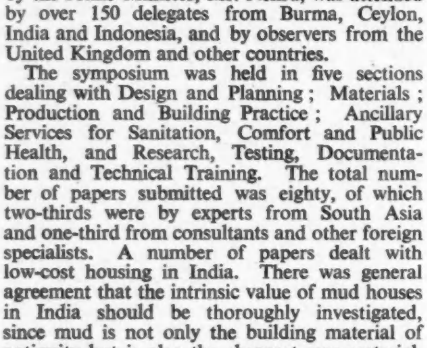
Indian Engineering News

(*By Our Indian Correspondent*)

Tropical Building Design and Construction

A symposium on "Scientific Principles and Their Application in Tropical Building and Construction" was held last December at the National Physical Laboratory, New Delhi, under the joint auspices of U.N.E.S.C.O. and the National Institute of Sciences of India. The symposium whose proceedings were inaugurated by the Prime Minister, Mr. Nehru, was attended by over 150 delegates from Burma, Ceylon, India and Indonesia, and by observers from the United Kingdom and other countries.

The symposium was held in five sections dealing with Design and Planning; Materials; Production and Building Practice; Ancillary Services for Sanitation, Comfort and Public Health, and Research, Testing, Documentation and Technical Training. The total number of papers submitted was eighty, of which two-thirds were by experts from South Asia and one-third from consultants and other foreign specialists. A number of papers dealt with low-cost housing in India. There was general agreement that the intrinsic value of mud houses in India should be thoroughly investigated, since mud is not only the building material of antiquity but is also the cheapest raw material. Certain defects in mud houses, such as crumbling, cracking, scaling and erosion can be remedied by adding small amounts of substances like lime, cement and bituminous compounds, which stabilise the earth. The cement in soil not only stabilises the latter but gives good key for plastering. About 3 to 5 per cent cement can



20 per cent cement is replaced in pozzuolanic concretes.

Comparative Strength of Concretes

be used advantageously with suitable soil and experiments show that ramming up the walls with soil-cement mix between suitable forms works out better than precast soil-cement bricks.

Experiments on the use of bamboo as reinforcement indicate that seasoned bamboo treated with brine gives better bond with concrete than normal wood or untreated bamboo. The load carrying capacity is found to be optimum for 3 to 4 per cent reinforcement. Woven bamboo mats have also been found to be good substitutes for steel mesh and numerous temporary refugee huts have been built in the Punjab and elsewhere with bamboo mats sprayed over with gunite concrete.

Great strides have been made recently in the research on pozzuolanic concrete for dams and irrigation works in India. Where a large volume of mass concrete is used, suitable pozzuolanic admixture can replace about 20 per cent of cement to effect considerable economy and secure other engineering advantages such as increasing workability, lowering heat generation and resistance to sulphate reaction. Most of the engineering laboratories in India have been conducting research on *surki* (brick powder) and its use as a pozzuolan. *Surki* has been used in many dams with great success in the south of India, but so far it has not been possible to extend its use to projects in the north. Where geologic formation is favourable, local shale—a metamorphosed form of clay—has been tried with considerable success. In either case (*surki* or shale), the basic material is clay in one form or another and it has been found that underburnt bricks yield better *surki* than burnt ones. The lime released from the cement in the concrete mix reacts with the pozzuolanic admixture to make the binding and thus the fineness of the material is one of the major criteria for effectiveness. Sandy bricks and overburnt bricks are difficult to grind into desired fineness and therefore less effective as pozzuolan. Comparison with plain cement concrete, shown in the diagram, indicates that while for the first four or five weeks *surki* concrete has only half the compressive strength of plain cement concrete, it rapidly approaches and slightly exceeds the latter's strength by the end of twelve or thirteen weeks.

The following are some of the conclusions reached at the symposium: the importance of layout in relation to the physical feature of the site, particularly contours, should receive due consideration for economic and sanitary reasons; stabilised soil has great potentialities in many areas of the region and its use should receive wider publicity; bamboo should be tried as a substitute for steel in reinforcing concrete and as building material for walling, &c.; the use of laminated and treated timber should be encouraged. The conference also laid great stress on ancillary services, such as water supply, drainage, sewage disposal and lighting.

Report on Scientific Research.

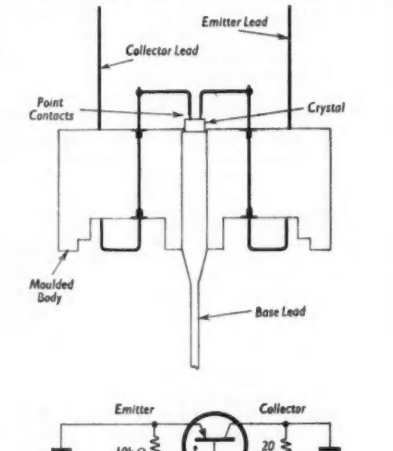
Three more national laboratories, the Central Road Research Institute at Delhi, the Central Electro-Chemical Research Institute at Karaikudi, and the Central Leather Research Institute at Madras, have been opened bringing the total of such institutes to ten, according to the annual report of the Ministry of Natural Resources and Scientific Research for 1952–53. The research programme seems to be heavily concentrated in the field of applied chemistry and among the achievements listed are production of nicotine sulphate from tobacco waste, preparation of synthetic rice from fortified tapioca, thermal beneficiation of low-grade manganese ores, preparation of new synthetic drugs, discovery of new sources of tanning materials, beneficiation of low-grade coal, preparation of foam glass and chemical porcelain, discovery of a process for using waste furnace ash as a substitute for cement and recovery of uranium minerals from copper tailings. The Council of Scientific and Industrial Research is also financing more than ten research schemes in universities and other institutions and is proposing to establish a National Research Development Corporation for utilising the results of research in a practical way and following them up with pilot plant investigations.

The Atomic Energy Commission, whose main functions are to "protect the interests of the country in connection with atomic energy, to survey the country for minerals useful in the release of atomic energy and to take steps leading to its use in the industry," has been able to locate important deposits of uranium in Bihar and beryl in Rajasthan, Bihar and Delhi. The Commission, which was instrumental in establishing the rare earths factory at Alwaye, Travancore-Cochin has also decided to establish a pilot plant for the recovery of uranium minerals from copper tailings, a uranium-thorium plant for processing the residual cake containing thorium and uranium left over from monazite and a production unit for the manufacture of standard electronic equipment needed in nuclear work. The Physics Division of the Commission has acquired necessary equipment for nuclear research, including a 1,000,000V cyclotron, and under the direction of Professor H. J. Bhabha, F.R.S., is carrying out fundamental research on the properties of atomic nuclei and the behaviour of elementary particles.

Among other activities mentioned in the report are the setting up of a Mineral Advisory Board for "reviewing the production, internal distribution, consumption and export of minerals and advising on the research programme of the Geological Survey of India and the Indian Bureau of Mines," and the establishment of a Central Geophysical Institute for the study of problems connected with ground water resources and earthquakes. In this connection, it is pertinent to mention that the Government of India has entered into an agreement with the Government of the United States for technical help in carrying out a comprehensive survey of water resources, particularly in regions such as Saurastra and Rajasthan, which are periodically visited by extreme drought and consequent famine. The agreement, signed last week, is the fourth in the series of agreements under the Technical Co-operation plan through which the two governments are pooling their resources together for large-scale industrial and agricultural development of the country.

A Germanium Triode for Experimental and Prototype Equipment

A POINT-CONTACT germanium triode which has been shown by the research laboratories of The General Electric Company, Ltd., at recent exhibitions, is now in pilot plant production in the company's works and is available to equipment makers in sufficient quantities for experimental work and prototype equipment. The triode uses single crystal germanium, and the unit is hermetically sealed in a cylindrical metal can insulated from all electrodes. Flexible



Figs. 1 and 2—Transistor "GET 1"

leads are provided for the connections. The triode is suitable for use in amplifiers, oscillators and for electronic switching applications. Its low power consumption and electrical characteristics make it particularly suitable for digital computer work.

The accompanying illustrations show a section through the new transistor and a typical circuit based on it (Figs. 1 and 2). Static characteristic curves are reproduced in Fig. 3. From these

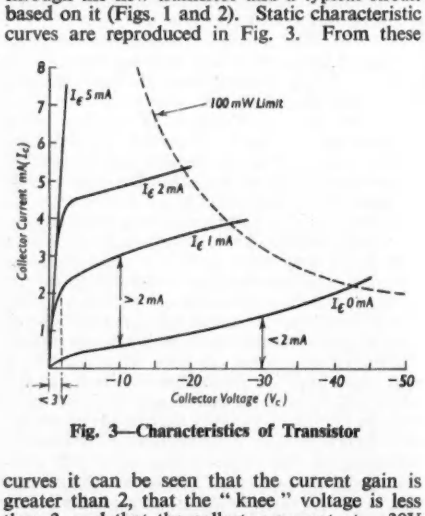


Fig. 3—Characteristics of Transistor

curves it can be seen that the current gain is greater than 2, that the "knee" voltage is less than 3, and that the collector current at −30V for zero emitter bias is less than 2mA. The maximum d.c. collector voltage is −50V, but normal operation is with much lower voltage, supplies of 22½V being typical. Whatever the collector voltage used the dissipation should be kept below 100mW.

Industrial and Labour Notes

Index of Industrial Production

The Treasury has announced that the index number of industrial production (1948=100), which is prepared every month by its central statistical office, has been estimated provisionally at 118 for all industries in April, compared with 124 in March. The figures for the corresponding months last year were 110 in April and 123 in March. The figures for April, both this year and last, were affected by the Easter holiday. The Treasury says that, on the basis of information so far received, the index for all industries in May—during which the Whitsun holiday fell—is expected to be 119 or 120.

Changes in Wage Rates

The Ministry of Labour has announced that changes in wage rates reported to have come into operation in the United Kingdom during May resulted in an aggregate increase estimated at approximately £71,000 in the weekly full-time wages of 441,000 workpeople. Among those who received wage increases were workers in the iron and steel industry, workers employed by the General Post Office in certain engineering, supplies and motor transport grades, manual workers in the non-trading services of local authorities in Scotland, and workers engaged in roadstone quarrying.

In the iron and steel industry proper, the wage increases were made under sliding-scale arrangements based on the index of retail prices, and in wire rope and iron and steel wire manufacture the existing "war addition" to wages was increased by 5s. a week for men and 3s. 9d. for women. Workpeople employed by the Post Office in certain engineering, supplies and motor transport grades received increases of 8s. a week for adult male workers and of 6s. 6d. a week for adult female workers. These increases were retrospective from January. Manual workers in the non-trading services of local authorities in Scotland received increases of 4s. a week for men and 3s. for women, which were also retrospective from January. The increase paid to roadstone quarrymen was 1½d. an hour.

These changes in wage rates did not affect the index of rates of wages (June 30, 1947=100), which, for all workers, has remained at 135 since February last. In the first five completed months of this year, changes in wage rates have resulted in increases aggregating £1,089,500 a week in the full-time wages of 3,927,500 workpeople. In the corresponding period of last year there was a net increase of £1,856,500 in the weekly full-time wages of 4,668,000 workpeople.

Aslib's Annual Conference

It has now been announced that the twenty-eighth annual conference of Aslib (Association of Special Libraries and Information Bureaux) will be held at the University, Nottingham, from September 11th to 14th. The presidential address, which Mrs. Barbara Wootton will deliver on Friday evening, September 11th, will be entitled "Some Problems of Communication." The conference programme includes sessions on Saturday and Sunday, September 12th and 13th, on "Special Library Training," "Administration Problems of a Special Library," and "Methods of Photographic Reproduction."

Particulars of the conference may be obtained from the Director of Aslib, 4, Palace Gate, London, W.8.

Government Loans for Fuel Saving Devices

An outline of the changes which are proposed in the Government's loan scheme to encourage the installation of industrial fuel saving equipment was given in the House of Commons last week by the Chancellor of the Exchequer, Mr. R. A. Butler, during the debate on the Finance Bill. The Chancellor said that the Government felt that something should be done to improve a system already introduced, and that modifications should be made in the method of allotting loans for fuel saving devices.

First of all, the Chancellor continued, it was proposed to extend the categories of equipment which were eligible for assistance under the loans as introduced originally and, secondly, it had been decided to increase the period during which the loans were repayable to the life of the equipment—for taxation purposes—up to a maximum of twenty years. Finally, it had been decided to make the loans free of interest for the first two years after the fuel saving equipment had been installed. That free period, the Chancellor added, should allow ample time for the equipment to be fully tried out and for its worth to be proved. The Chancellor explained that a leaflet giving full details of the modified scheme would be available shortly from the Ministry of Fuel and Power. The leaflet, he said, would give some idea of the categories of equipment eligible for loan.

Trade Disputes

Statistics which appear in the latest issue of the *Ministry of Labour Gazette* show that, in the month of May, there were 154 stoppages of work through industrial disputes in progress in the United Kingdom. They involved 18,600 workers and caused an aggregate loss during the month of 32,000 working days. Of the total number of stoppages, 110 occurred in the coal mining industry, five in the engineering industries, three in the vehicle building industry, nine in transport and communications, and twenty-seven in "all remaining industries and services." The Ministry says that 141 stoppages through disputes ended during May. Of that number sixty-five, involving 4900 workers, lasted not more than one day; thirty-nine, involving 4000 workers, lasted two days; nineteen, involving 3200 workers, lasted three days; ten, involving 2400 workers, lasted from four to six days, and eight stoppages, involving 2800 workers, lasted more than six days.

In the first five completed months of this year there were 720 stoppages of work through disputes reported to the Ministry of Labour. They involved 119,500 workers and caused an estimated loss of 588,000 working days. In the corresponding period of last year the 748 stoppages which were reported involved 156,800 workers and resulted in a loss of 694,000 working days.

The Coal Situation

Various questions about coal production and stocks were addressed to the Minister of Fuel and Power, Mr. Geoffrey Lloyd, in the House of Commons, on Monday last. In reply, the Minister said that, as a result of the Coronation holiday, about 1,500,000 tons of coal had been lost and it was estimated that the second week's holiday, which the miners were taking for the first time this year, would lose a further 3,500,000 tons.

That, the Minister continued, was the crux of our coal difficulties this year, and the main question was whether production could be increased sufficiently to offset it. During the first three months of this year production was bad, and up to Easter was only about 20,000 tons a week more than last year despite an extra 10,000 men in the industry. Nowhere, Mr. Lloyd said, was the seriousness of that appreciated more clearly than in the industry itself, and following the joint production campaign in the spring, coal production during the last two months, after making allowance for the extra holidays, had been higher by about 100,000 tons a week than the year before. Thanks to that improvement, he added, we had already gone some way to make up for the losses resulting from the extra holidays. That was most welcome, but the whole of the mining industry recognised that more coal was needed, especially in view of the rising trend of consumption. Concerted efforts would continue to be made by all concerned to raise stocks to the highest possible level before the winter. Mr. Lloyd ended his reply by saying that he was glad that there was anxiety at the present time about the coal situation, because it was justified, and it was very much better that we should be thoroughly anxious now than that we should be taken by surprise when the winter came. Everybody in the industry was working very hard in connection with the matter.

Figures published by the Ministry of Fuel and Power on Wednesday morning show that last week the saleable output of coal totalled 4,379,300 tons, of which 4,115,100 tons came from the deep mines and 264,200 tons from opencast workings. In the first twenty-five weeks of this year, ended June 27th, the saleable output of coal amounted to 110,692,800 tons, compared with 110,782,900 tons in the corresponding period of last year. In the week ended June 20th, total coal consumption, including exports and bunkers, amounted to 4,008,000 tons, and distributed stocks were 14,371,000 tons, compared with 15,747,000 tons on June 21st, 1952.

Steel Plate Supplies

The Minister of Supply, Mr. Duncan Sandys, was asked in Parliament last Monday what adjustments in the pattern of production and deliveries had been considered desirable by the interdepartmental committee on the allocation of steel plates. In reply, Mr. Sandys said that various steps had been taken with the object of ensuring that existing plate-making capacity was used to the full. In addition, arrangements had been made to import quantities of steel plate from abroad. As a result, there should be some progressive improvement in supplies.

In a further question, the Minister was asked to what extent the shortage of steel plates and forgings for the Railway Executive's rolling stock programme had now been overcome. Mr. Sandys said, in reply, that there had been an improvement in the deliveries of plates and forgings for that purpose, which, he understood, had enabled the Railway Executive to restore part of the cut it had been obliged to make in its rolling stock production programme.

Trade Unions in Canada

A report on labour organisation, which has been published recently by the Canadian Department of Labour, contains some statistical details of the membership and organisation of trade unions in Canada at the beginning of 1952. At that time, the report states, the total membership of Canadian trade unions was 1,146,121, which indicated an increase of about 11·4 per cent over the preceding year. Of the total membership in January, 1952, 796,016 were organised in 3720 branches of international trade unions which had their headquarters in the U.S.A.

The report shows that rather more than 30 per cent of non-agricultural workers in Canada were members of trade unions at the beginning of last year. This, it is stated, was a higher proportion than at any time previously, and indicates that trade unions in Canada are now drawing their members from almost all sections of industry. But the statistics have revealed that the extent of union membership varies considerably between individual industries and industry groups. In the manufacturing industries of Canada, trade unionists last year numbered 434,200, which was the largest number in any group, although it represented only about 40 per cent of the total number of workers employed in the manufacturing industries. In the transport industry group, the number of union members was 231,850, and represented nearly two-thirds of the total number of workers in the group. In the "iron and steel products" industry group there were 72,800 trade union members, and in mining, 50,900.

Other information in the report is that the largest of the three central organisations of trade unions in Canada is the Trades and Labour Congress of Canada. It is mainly representative of the craft unions, and at the beginning of last year had a representative membership of about 523,000.

Notes and Memoranda

Rail and Road

LOCOMOTIVE TESTING BULLETINS.—The fifth locomotive testing bulletin which has just been published by British Railways, deals with "Performance and Efficiency Tests with Exhaust Steam Injector: British Railways Standard Class '7,' Two-Cylinder, 4–6–2 Mixed Traffic Locomotive." This bulletin is now on sale through the Publicity Officer, Railway Executive, Room 323, 222, Marylebone Road, London, N.W.1, price 10s. net.

BUDAPEST UNDERGROUND.—We are informed by the Hungarian News Service that in Budapest work is well advanced on the 5-mile long underground, part of which is due to be in operation by the end of 1954. Connecting the People's Stadium and the East Station with the South Station, it will be able to carry 300,000 passengers a day and relieve heavily congested surface transport. The line will run at an average depth of 200ft below street level. A considerable amount of Soviet equipment is being used in the construction work and Soviet technical advice has been given to the Hungarian authorities.

APPRENTICES SCHOOL AT WAGON WORKS.—British Railways announce that a new school for apprentices is to be set up at Earlestown Wagon Works, Lancashire, the largest railway wagon and container works in the country. The works require a normal complement of 176 apprentices and the purpose of the school is to attract sufficient trainees, give them a twelve months' course of preliminary practical and theoretical instruction, and then to select individual apprentices for the skilled craft for which they show the most aptitude. The overall training period to a particular trade will take five years. The school will provide facilities for forty boys at a time and will consist of a workshop, class room, instructors' room, stores and amenities. An existing works building is to be adapted to accommodate the school and the reconstruction work will start this month. It is expected to be ready for use early in 1954. The decision to provide this school follows the successful experience gained with the existing school at Derby. A similar school is to be provided at Wolverton, and at Crewe one is also being built for training apprentices for the locomotive and other technical departments.

Air and Water

UNION CASTLE LINE.—We are informed by the Union Castle Line that its liners engaged in the intermediate and round-Africa services, will continue to call at Rotterdam, at approximately monthly intervals, after leaving London, until the end of the year.

GAS TURBINE MODEL.—A one-eighth scale sectioned model of gas turbine fitted in 1951 in the 12,250 tons deadweight diesel-electric oil tanker "Auris," owned by the Anglo Saxon Oil Company, Ltd., has been presented by the Shell Petroleum Company, Ltd., to the Science Museum, South Kensington, London.

LAUNCH OF FRIGATE.—On Thursday, June 25th, the first of a new design of air direction frigates, H.M.S. "Salisbury," was launched from Devonport dockyard. The frigate, which has an extreme length of 340ft by 40ft beam, will be powered by Admiralty Standard Range diesel engines and the main armament will consist of two 4·5in guns.

RETIREMENT OF ENGINEERING MANAGER.—William Doxford and Sons, Ltd., announces that Mr. W. H. Purdie, the director and general manager of the engineering department, will retire on November 30th, at his own request, but will retain his seat on the board and be available in a consultative capacity. Mr. A. Storey, a director of North Eastern Marine Engineering Company (1938), Ltd., has been appointed a director and deputy general manager and will succeed Mr. Purdie on his retirement.

LINER CONVERSIONS.—The new 28,000-ton liners "Arcadia" and "Iberia" are expected to enter the Australian service of the P. and O. Steam Navigation Company in 1954, and with their entry the company has decided to convert the "Strathaird" and "Strathnaver" into one class ships carrying tourist passengers only. At present these ships carry 570 first and 470 tourist-class passengers on the run serving India, Ceylon and Australia. After conversion they will carry 1200 tourist-class passengers.

Miscellanea

MR. S. G. RATTEE.—We have learned with deep regret of the death of Mr. Stanley G. Rattee, A.M.I.E.E., of 27, West Avenue, Wallington, Surrey, which occurred on Saturday last, June 27th. For the past thirteen years Mr. Rattee had been editor of *The Electrical Journal*. He was also editor of *The Electrician Blue Book* and of *Electricity Undertakings of the World*.

THE LATE MR. A. F. BOCK.—We regret to announce the sudden death of Mr. Arthur F. Bock, which took place at his home at Sutton Coldfield on June 21st. Mr. Bock had been manager of the Birmingham office of Metropolitan-Vickers Electrical Company, Ltd., for twenty-six years until his retirement last October. He had had forty-five years' service with the company.

IRON AND STEEL APPOINTED DAY.—The Minister of Supply, Mr. Duncan Sandys, announced in Parliament last Monday that the "appointed day" under the Iron and Steel Act, 1953, would be July 13th. That decision, he said, resulted from a joint recommendation of the chairman of the Iron and Steel Board and the chairman of the Iron and Steel Holding and Realisation Agency.

"THE IRONMONGER."—Nearly twenty years ago Mr. P. L. Garrett became editor of *The Ironmonger*; on June 30th, he retired. Mr. Garrett first joined the staff of *The Ironmonger* as long ago as 1914. In due course he became assistant editor and he succeeded Mr. W. A. Young as editor in 1934. Mr. P. W. Bax, who was Mr. Garrett's assistant editor, now becomes editor of the journal.

"PLATFORMING" UNIT.—We are informed by the Shell Petroleum Company, Ltd., that a large "platforming" unit is now in operation at the company's Houston refinery, Texas, U.S.A. The plant has been designed to produce either petrol or benzene and toluene, but present production is confined to producing 16 million gallons of benzene or 28 million gallons of toluene per annum.

HYDRAULIC BENDING MACHINES.—The General Electric Company, Ltd., announces that it is now marketing hydraulic machines for bending heavy gauge conduit and flat bars. The standard machine has a capacity for bending unloaded, cold, heavy gauge conduit up to 2in diameter to an angle of 90 deg., and with an extension ram, up to 160 deg. Machines of other sizes incorporate rams to enable rapid bending up to 180 deg.

CHEMICAL ENGINEERING CONFERENCE.—The programme has now been issued by the Institution of Chemical Engineers of the conference which is to be held at Olympia from September 7th to September 11th next, at the time of the Chemical Plant Exhibition. Eight papers are to be read at the conference and on September 9th a discussion on British chemical engineering in the light of recently published reports is to be opened by Sir Harold Hartley and Mr. J. Grange Moore.

AN INSTRUMENT SOLDERING IRON.—A new soldering iron particularly intended for use in the compact assemblies employed in radio, television, electronic and similar units, has been introduced by W. T. Henley's Telegraph Works Company, Ltd., 51, Hatton Garden, London, E.C.1. In this tool, which weighs only 3¼ oz., the bit and the holder are made of high conductivity drawn copper and a replaceable steel-cased element is enclosed in the holder. The bit is ⅛in diameter and the tool is 9in long overall.

UNIVERSITY SCHOLARSHIP AWARDS.—The first scholarships given by the Apprenticeship and Training Council for the Electrical Contracting Industry have been awarded this year. These scholarships, tenable for three years, for degree courses at a university or for Higher National Diploma Courses at a technical college, and covering fees, examination expenses and maintenance allowances, have been won by David Arthur Cole, a student at Poplar Technical College, and Brian Horace Walter, a student at Maidstone Technical College.

CHEMICAL ENGINEERING FEDERATION.—A European Federation of Chemical Engineering was formally inaugurated at a Foundation Meeting held in the Maison de la Chimie in Paris on June 20, 1953. The purpose of this Federation is to promote European co-operation in the fields of chemical engineering and equipment. The Federation owes its origin to efforts commenced in 1951, and which assumed a more concrete form during the course of the European Convention for Chemical Engineering and the ACHEMA X Chemical Engineering and Equipment Exhibition, which took place in 1952.

A TIMBER STORAGE SHED AT HULL.—Contracts have been placed and work has started on the construction in timber of a timber storage shed with a capacity of up to 3000 standards at Victoria Dock, Hull, for Horsley Smith and Co., Ltd. The building, which is 445ft long by 163ft wide, has an almost flat corrugated asbestos roof without valley gutters. It is divided lengthwise into three sections, by columns set at 55ft centres. The outer two sections are the timber stacking bays, the centre section being a three-rail and road track 45ft wide. All loading, handling and stacking of timber will be effected under cover and there will be but little obstruction from the internal columns.

EXPERIMENTAL TRANSMITTER FOR TELEVISION STUDENTS.—We learn that the Television Society has built an experimental 405-line transmitter to operate on 427Mc/s, with a peak power of 12W. The equipment is being installed at the Norwood Technical College, and besides providing a test signal for members interested in u.h.f. reception it will serve as a demonstration for students attending the television training classes in the College. The call sign is G3CTS/T, and it is expected to put a signal on the air by the end of July. The Society also has under consideration a 625-line transmitter, which will be designed and operated in collaboration with the radio industry. It will enable commercial receivers built to continental standard to be tested under working conditions. It is not intended that either transmitter shall be operated as a commercial station.

NEW FACTORY AT CRAWLEY.—With the advancement of the Crawley New Town project several of the factories there are now occupied and others are well under construction. Recently the foundation stone of another factory—that of the Telcon Metals factory of the Telegraph Construction and Maintenance Company, Ltd.—was laid at Manor Royal, Crawley. This factory is to manufacture metal alloys specifically suited to the electrical and radio industries, which are at present being made at the company's parent works at Greenwich. Following the stone-laying ceremony, at which Lord Colgrain officiated, the guests of the company were entertained to luncheon at the Tilgate Forest Hotel, Crawley. The success of the company at Crawley was proposed by Sir Thomas Bennett, chairman of the Crawley Development Corporation, and Lord Colgrain, who is chairman of the Telegraph Construction and Maintenance Company, Ltd., responded.

COLLIERY HAULAGE AND WINDING GEAR.—The Ministry of Fuel and Power has issued a research report entitled "The Heat-Treatment of Colliery Haulage and Winding Gear," by R. Jeffrey. This report first outlines the regulations and recommendations dealing with the heat-treatment of chains, rings, hooks, shackles and other lifting tackle set out in the Coal Mines Act, the Factories Act, and in safety pamphlets. After explaining the principles and methods of heat-treatment, the effects of the different kinds of treatment on the materials in general use are discussed. The advantages of careful heat-treatment after manufacture are indicated. The merits of different treatments during service are discussed and it is shown that the reliability of wrought iron and mild steel gear is greater if normalising is used instead of annealing. The benefits associated with hardened and tempered steels are described and it is pointed out that the full advantages of any heat-treatment will only be obtained when suitable furnaces and ancillary equipment are employed.

ROAD RESEARCH LABORATORY'S LECTURE COURSES.—Lecture courses will be held at the Road Research Laboratory, Harmondsworth, during the autumn and winter of 1953–54. As in previous years, they will deal with the fundamental properties of road materials and will include the most recent results of research and their application to modern practice; the Laboratory's Traffic and Safety Division will also hold a lecture course. The courses to be held by the Road Materials and Construction Divisions are entitled: soil mechanics; concrete; tar and bituminous materials; and soil stabilisation with cement. The course at the Laboratory's Traffic and Safety Division, Langley Hall, near Slough, will include the most recent results of research and thought on factors relevant to traffic engineering and road safety; opportunities for discussion will be afforded. This latter course is designed for senior officials, or those specially concerned with matters related to traffic engineering and/or road safety. Each course will be self-contained, and an inclusive fee of £10 10s. will be charged for it. Forms of application can be obtained from the Director, Road Research Laboratory, Harmondsworth, Middlesex.

Personal and Business

MR. J. JENKINS has joined the sales staff of the Belmos Company, Ltd., Bellshill, Lanarkshire.

MR. J. MAXWELL LAING has been appointed general sales manager of the Audley Engineering Company, Ltd., Newport, Salop.

MR. STEPHEN BAKER has been appointed service manager of Davy and United Engineering Company, Ltd., Park Iron Works, Sheffield, 4.

MR. J. R. C. JOHNSON has been appointed manager of the contracts division of the Marconi International Marine Communication Company, Ltd.

MR. C. ANDERTON has been appointed general sales manager of the agricultural division of Clifford Aero and Auto, Ltd., Hall Green, Birmingham.

VICKERS-ARMSTRONGS, Ltd., announces that Mr. G. H. Houlden, the general manager of the company's naval yard at Walker, has been appointed a director.

MR. A. F. C. GARDNER has been appointed Northern general manager of Gibbons Brothers, Ltd., Dudley. His office address is "Cranbourne," Egglescliffe, near Stockton-on-Tees.

FERODO, Ltd., Chapel-en-le-Frith, announces the following appointments:—Mr. F. L. Harrap, export sales director; Mr. G. S. Sutcliffe, home sales director; Mr. S. C. Clifford, works director.

JOHNSON AND PHILLIPS, Ltd., Charlton, S.E.7, announces the retirement of its chief accountant, Mr. Hugh E. Easton. Mr. Easton has completed nearly sixty years' service with the company.

MR. F. H. BEASANT, M.I.Mech.E., M.I.E.E., has been appointed to the board of the Anti-Attrition Metal group of companies. He will be responsible for directing all the sales and associated activities of the group from the London office at 56, Victoria Street, S.W.1.

HERCULES POWDER COMPANY, Ltd., 140, Park Lane, London, W.1, states that it has concluded an agreement to act as sole distributor for the United Kingdom of "Akulon" injection and extrusion moulding material manufactured by Algemene Kunstzijde Unie, N.V., Arnhem, Holland.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., Rugby, states that Mr. Hugh McC. Jack has retired from the position of chief electrical engineer, but continues to serve on the board of the company. Mr. G. S. C. Lucas, chief assistant to Mr. Jack, has been appointed a director and chief electrical engineer.

THE CANADIAN PACIFIC RAILWAY announces the appointment of Mr. C. E. Lister as general manager for the prairie region. Mr. J. W. Wilkes has been appointed general superintendent of the Saskatchewan district, and Mr. D. M. Dunlop has been appointed superintendent of the Moose Jaw division.

THE STEEL, PEECH AND TOZER branch of the United Steel Companies, Ltd., announces the retirement of Mr. Herbert McWhinnie from the position of general sales manager. He will continue with the company for a time to advise on sales development. The post of general sales manager at the branch has now been discontinued and all the departments which are responsible to the commercial director will be supervised by Mr. J. Mackenzie-Mair, assistant commercial manager.

British Patent Specifications

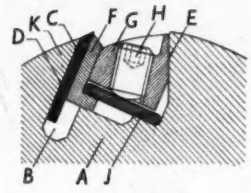
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application : the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

MACHINE TOOLS

692,534. October 8, 1951.—CUTTER SHAFT FOR WOOD PLANING MACHINES, Georg Fischer Aktiengesellschaft, Schaffhausen, Switzerland.

The invention relates to a cutter shaft for wood planing machines, in which each cutter is held by means of pressure screws in an outwardly tapering groove in the cutter shaft body by means of a shim and a conical pressure block. The cutter shaft body *A* shown in the drawing, is formed at the periphery with four grooves *B* for accommodating the cutters *C*, the flanks *D* and *E* of the grooves having an outwardly tapering cross section. In each of the grooves is a cutter *C*, an angularly shaped shim *F*, the short arm of which bears on the cutter shaft body *A*, and a conical pressure block *G* with a number of pressure



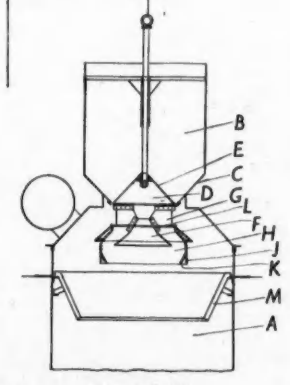
No. 692,534

screws *H* distributed over the entire length of the cutter shaft. As shown, a resilient support *J* along the cutter shaft is mounted with one end of its long face on the cutter shaft body *A* and the other end on the short arm of the angular shim, the central portion of the resilient support on which the pressure screws *H* bear being capable of flexing. On tightening the pressure screws the wedge-shaped pressure block *G* is pressed outwardly and there is produced a compressive effect, by which the shim and the cutter are pressed on to the flank *D* of the lip *K* of the cutter shaft. A part of the force of reaction of the pressure screws *H* presses the short arm of the shim *F* on to the cutter shaft body and, with further tightening of the pressure screws the resilient support *J* is flexed. A modified construction is also shown in the specification.—*June* 10, 1953.

FURNACES

692,648. January 15, 1951.—FEEDING DEVICES FOR SHAFT FURNACES, Süddeutsche Kalkstickstoff-Werke Aktiengesellschaft, 7, Fabrikstrasse, Trostberg/Obb, Germany.

The drawing shows the sealing bell in a neutral position. At the upper rim of the shaft furnace *A* is a hopper *B*, which is sealed off from the shaft furnace by means of a funnel *C* and a two-part sealing bell *D*. The sealing bell has an upper cone surface *E* and a lower distribution cone *F* connected with the upper



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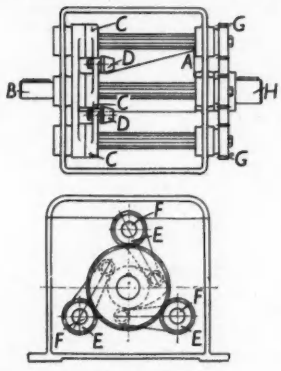
bell part by a holding plate *G*. The bell hangs centrally on a spindle having at the upper end a thimble, to which a cable is fastened. The cable leads to a winch, by which the sealing bell is raised and lowered. On the holding plate *G* is fitted a basket grate *H*, which consists of single-grate bars *J*. Each second-grate bar *K* is curved at its lower end in towards the middle of the furnace. The grate bars are supported by a ring *L*, which is substantially horizontal and the diameter of which can be varied to alter the distance between each grate bar. At the upper end of the shaft furnace is a crown of obliquely-lying, wall-protective rods *M*, which act as a sieve grate and keep large component pieces of fuel or charge from the furnace edge. Material sliding down from the lower distributor cone falls against the basket grate, allowing the finer material to pass through and leading the coarser material towards the middle of the furnace.—*June* 10, 1953.

POWER TRANSMISSION

692,557. October 26, 1949.—A VARIABLE-SPEED GEAR, Roy Shackleton, 5, Peas Acre, Micklethwaite, near Bingley, Yorkshire.

The variable-speed gear is made with the object of obtaining an output drive of infinite range from the power supplied to the device. The parts employed are a small number of simple cams, levers, pinion wheels, shafts and springs. In the accompanying drawing is shown a plan and end view of a variable-speed gear according to the invention. The cam cylinder *A* and drive shaft *B* turn as one unit. The cam cylinder rotates and lifts each lever *C* in turn by pressure upon anti-friction contact roller *D*. Each lever pivots upon a roller freewheel *E*, shown in the lower view. The pressure lift from each cam actuates lever *E* and lever shaft *F*, also pinion *G*. All



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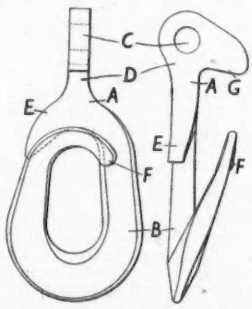
move together as one unit the solid drive way of freewheel movement ; lever return is made by spring pressure as free movement. As pinion *G* is in constant mesh with final drive *H*, all lever movements assist in turn to rotate *H* in one direction only. Levers are positioned about cam cylinder *A* to collect pressure impulses evenly, and so keep turning *H* constantly without snatch or pauses. At small end of cam lift this rotation is very slow, but endwise movement of *A* presents the higher portion of tapered cams, and lever movement increases. When *A* is lifting its greatest all levers are actuating fully the total power impulses given up by *A*, and available at *H* as revolutions, now equal the rotation of the input shaft, and a one-to-one ratio has been attained from a neutral position shown in the upper view, where all levers are at rest on a parallel portion of cylinder, just beyond cam contact at the low end of cam taper, so providing a no-work position of the gear.—*June* 10, 1953.

CRANES AND LIFTING DEVICES

692,635. November 1, 1950.—CRANE HOOK, The River Wear Commissioners, St. Thomas Street, Sunderland. (*Inventor : Harry Wilson.*)

Referring to the drawings, it will be seen that the shank of the hook *A* and the hook portion *B* comprises a single-turn helix. It is of oval form with its major axis vertical and passing through an eye *C* in



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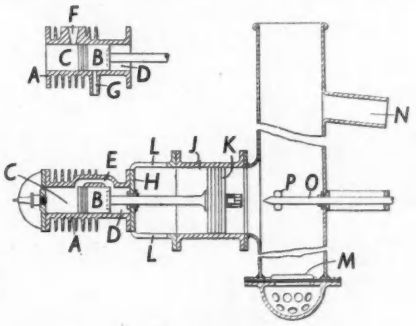
the upper end *D* of the shank for attachment to the crane rope. The helix comprises a short lateral curved abutment *E* projecting from one side of the shank, and the major portion *B* projecting from the other side of the shank in substantially the same plane and extends as a complete turn of a helix of diminishing cross section which terminates in a rounded end *F* at a slightly lower level than that of the abutment *E*. The pitch of the helix is such that the end of the turn is spaced from the beginning to leave sufficient clearance for the easy passage of a sling or chain. Above the hook opening is a lug *G*, which prevents the upper portion from catching under the coaming round the ship's hold as it is being withdrawn. With the hook described engagement with the sling or chain is greatly facilitated, as all that is necessary is to throw the sling or chain against the side of the shank *A* from which the helix is generated. It then slips automatically into the space between the turns, changes its direction as it contacts the lower portion of the inside of the hook and is then virtually impossible for unintentional disengagement to occur.—*June* 10, 1953.

PUMPS

692,487. June 27, 1950.—INTERNAL COMBUSTION PUMP MECHANISMS, William Henry Webb, King's Oak, Rowtown, Addlestone, Surrey.

In the drawing there is shown a combustion cylinder *A* fitted with a spark plug and divided by a piston *B* into a combustion chamber *C* and scavenge chamber *D* connected by a transfer port *E* in the wall of cylinder, these chambers being served by an exhaust port *F* and inlet port *G* respectively. The scavenge chamber *D*, which also serves as an air cushion for piston *B* at the end of each forward stroke, terminates in a wall *H* forming on a pump cylinder *J* a mounting for cylinder *A*. A piston *K* larger in diameter than piston *B* operates in cylinder *J*, the pistons being linked together by a rod sliding in a sleeve mounted in wall *H*. That part of the cylinder behind piston *K* is open to the atmosphere by way of apertures *L*, whilst the other part of the cylinder, in front of the piston, forms a T-joint with a vertical pipe provided with a foot valve *M*, a strainer, a delivery spout *N* and an upper extension. In the wall of the pipe opposite cylinder *J* there is located a starting handle in



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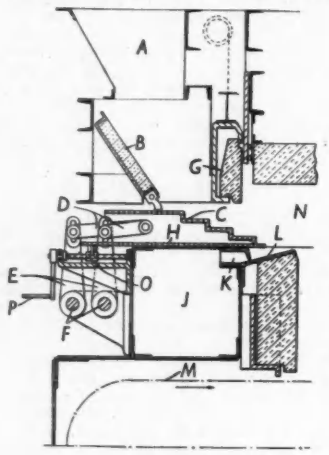
the form of a rod *O* having a bayonet end *P* for dogging into a complementary boss on the piston. In operation the vertical pipe being at least partly filled with water whilst the foot valve *M* dips into a river. A forward stroke of the piston assembly results in an upward surge of water in the vertical pipe. At the end of the stroke the momentum generated will cause water to be drawn through the foot valve *M* until motion of the water in the pipe subsides and eventually reverses to thrust back the piston assembly in readiness for another forward stroke. On the return stroke of the piston assembly the water in the vertical pipe subsides below the level of the spout, except in those cases where the parts are so proportioned that this stroke is completed prior to or immediately after the drainage of water from the upper extension, in which case there is a continuous delivery. Various modifications are described in the specification.—*June* 10, 1953.

FURNACES

692,645. December 15, 1950.—MECHANICAL STOKERS, Babcock and Wilcox, Ltd., Babcock House, Farringdon Street, London, E.C.4.

In combustion apparatus of the kind specified, regulating means are provided for varying the track lengths on the feed plate over which the fuel particles move. In the drawing a hopper *A* discharges coal over a chute *B* to feeding rams *C* disposed side by side and coupled by pushers *D* and levers *E* to oscillating shafts *F*, operation of which effects forward and backward movements of the rams, the amplitudes of the movements being adjustable. A regulator door *G* may be raised or lowered in order to vary the gap through which the rams project the coal. The rams move on an adjustable slide plate *H*, below which is an air chamber *J* connected with a supply of compressed air and provided at its rearward side with nozzles *K* for the discharge of air over the upwardly inclined feed plate *L*. Extending below the hopper is the front portion of a travelling grate *M*, and in operation fuel which falls from the hopper and

is conveyed towards the furnace chamber *N* by the rams falls over the inner edge of the slide plate *H* on to the feed plate *L*, which provides a track along which the fuel particles are carried by the air discharged from the nozzles *K* into the furnace chamber, where those particles which are not burned in suspension are deposited on the travelling grate *M*. The slide plate *H* is movable inwardly and outwardly by a



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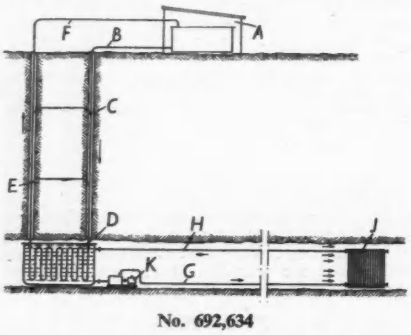
nut *O* through a spindle which may be turned by a handle *P*. The distances through which the fuel particles are projected are greatest when the plate *H* is drawn outward to such a degree that the fuel drops on to the feed plate *L* immediately in front of the nozzles *K*. The further the plate *H* is drawn inward the further in is the region of the feed plate on to which the fuel falls and the shorter therefore are the tracks of the fuel particles on the feed plate and the distances through which the particles are projected before they reach the fuel bed on the grate.—*June* 10, 1953.

MINING ENGINEERING

692,634. October 31, 1950.—CONDITIONING AIR IN PITS, C. Deilmann Bergbau G.m.b.H., Dortmund Kurl, Germany.

The invention is based in principle on the method in which a cold carrier is introduced into the pit, circulated and returned from below the surface after having absorbed heat from the pit air. In the drawing *A* is the cooling installation on the surface and *B* is the delivery pipeline for the liquid cooling medium produced by condensation in the cooling installation. The cooling medium passes through the lined borehole *C* to the bottom of the pit and, after passing through the brine cooler *D* mounted directly beneath the delivery borehole, is immediately returned to the surface through the return pipe *F* in the borehole *E*



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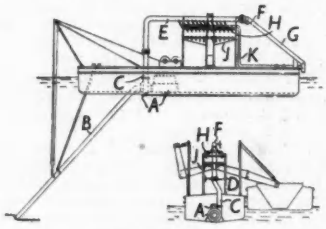
to the installation on the surface. The pipes *G* and *H* for the low-pressure circulation of the solution cooled in the cooler *D* are connected to the brine cooler, the solution passing through air coolers *J* distributed in the pit. A pump *K* circulates the solution. A modified design is also shown in the specification with the evaporator arranged underground supplying three working faces.—*June* 10, 1953.

DREDGERS

692,668. May 24, 1951.—SUCTION DREDGERS, N.V. Aannemersbedrijf Voorheen Firma T. Den Breejen van den Bout, Berg en Dal, Groesbeek, The Netherlands.

As shown by the drawings, the dredger is equipped with an engine operated centrifugal pump *A*. With the suction side of the pump there is connected the pipe *B*, suspended in tackles which are operated by winches, as shown. The delivery pipe *C* of the pump rises vertically, except for a bend which brings it to the centre of the vessel. It then passes a valve *D*. The delivery pipe passes into a horizontal distributing conduit *E* lying at a considerable distance above the deck of the vessel and connected through a valve *F* with an over-flow pipe *G*. At a slightly lower level and to the side of the distributing conduit *E* there are arranged two series, each of twelve similar cyclones *H*, each with a conical lower end, and having tangential inlets connected with pipes branching off from the conduit. When the valve *D* is opened and the valve *F* is closed, all the dredging suspension sucked through the pump enters the cyclones *H*.



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The cyclones are disposed above a collecting tank or tray *J*, which receives the thickened suspension leaving the cyclones at the bottom. From this collecting tank the suspension can be transferred in the usual manner through tip chutes or into barges moored alongside the vessel, as shown in the lower view. The water separated off in the cyclones, which has been freed of solid material, is discharged via the pipe *K*. The stream of suspension supplied through the pump is therefore passed uninterruptedly, without any additional transporting medium, through the cyclones, thickened and further discharged.—*June* 10, 1953.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

SOLID DRAWN COPPER AND COPPER ALLOY TUBES

No. 378 : 1953. Price 2s. 6d. The recently published revised edition of B.S. 378 supersedes the 1941 edition. The previous issue covered solid drawn 70/30 brass and 70/29/1 brass tubes. The present revision includes in addition to these alloys, tubes in copper, aluminium brass, copper-nickel and aluminium bronze (7 per cent aluminium). The requirements for tubes for screwed glands and screwed glands for condensers included in the earlier edition have, however, been omitted, and will form the subject of a separate standard.

METHODS OF TEST FOR STABILISED SOILS

No. 1924 : 1953. Price 12s. 6d. This new standard will be of interest to all concerned with stabilising soil as a foundation, particularly for roads, for runways of aerodromes, for the foundations of buildings and for such constructions as sea-walls. Stabilised soil is any natural material which has been modified to improve and to maintain its load-carrying capacity and resistance to weathering. This may be achieved either by controlling the grading or by the addition of stabilisers, defined as any materials, solid or fluid, which either cement the soil particles together or waterproof the soil mass and prevent water absorption, or act in both ways simultaneously. Solid stabilisers include, for example, cements, limes, straight run bitumens and resins ; fluid stabilisers include cut-back bitumens, tars, bituminous emulsions and aqueous solutions of chemicals.

This standard supplements B.S. 1377 : "Methods of Test for Soil Classification and Compaction," and describes additional tests for stabilised soils. It covers all types of stabilisers which are at present in common use and all types of soil of which 80 per cent or more of the particles pass a 1½in B.S. sieve. The standard includes the following methods : preparation of samples, determination of moisture content, dry density/moisture content relationship, dry density, unconfined compressive strength, and the cylinder penetration ratio.

The California bearing ratio is not included. The cylinder penetration test, which is intended to give a measure of the stability of the stabilised soil and is not intended to be used in conjunction with curves for pavement design purposes, is similar to the California bearing ratio test but with certain essential differences. In the cylinder penetration test the specimens, when compacted in the moulds, are wax coated and allowed to cure for seven days ; the specimens are not soaked and the result of the test is based on a penetration of 0·1in. Typical forms are included showing how results may be calculated and recorded.

Launches and Trial Trips

ALKOR, oil tanker ; built by the Netherlands Dock and Shipbuilding Company, Amsterdam, for the Alvion Steamship Company, Ltd. ; length between perpendiculars 565ft 6in, breadth 76ft 6in, depth 42ft, draught summer freeboard 32ft 0¾in, deadweight 24,000 tons, service speed 14·5 knots ; N.D.S.M. double-acting, two-stroke diesel engine, seven cylinders, 7400 h.p. at 117 r.p.m. ; two Scotch boilers, one 200kW diesel-driven generator, one 200kW steam-driven generator. Launch June 20th.

NORDEPIC, trawler ; built by the Goole Shipbuilding and Repairing Company, Ltd., for the North Eastern Fish Industries, Ltd., of Newfoundland ; length 105ft, breadth 23ft 6in, depth 11ft 6in ; Crossley H.R.N. diesel engine, 450 b.h.p. at 310 r.p.m., trial speed 10·3 knots. Trial June 24th.

TEESWOOD, cargo ship ; built by the Burntisland Shipbuilding Company, Ltd., for the Constantine Shipping Company, Ltd. ; length between perpendiculars 214ft 6in, breadth 35ft 4in, depth moulded 16ft, deadweight 1560 tons, draught loaded 15ft 8½in ; British Polar diesel engine, five cylinders 340mm diameter by 570mm stroke, 800 b.h.p. at 250 r.p.m. ; two 35kW and one 60kW diesel-driven generators. Launch June 25th.

NESSBANK, cargo ship ; built by Harland and Wolff, Ltd., at Belfast, for the Andrew Weir Shipping and Trading Company, Ltd. ; length overall 450ft, length between perpendiculars 425ft, breadth moulded 59ft, depth moulded to shelter deck 38ft 3in, gross tonnage 5800 ; two steel decks, seven water-tight bulkheads, deep tanks forward and aft of machinery space, four cargo holds, derricks include one to lift 25 tons ; three 175kW diesel-driven generators ; Harland-B. and W. two-stroke, single-acting, opposed-piston, deisel engine, six cylinders 620mm diameter by 1870mm combined stroke, 118 r.p.m. ; two vertical boilers. Trial June 25th.

Contracts

BRITISH INSULATED CALLENDER'S CABLES, Ltd., has been awarded the contract for the submarine cable-laying trials which will take place shortly off the Dover coast, when two half-mile lengths of cable will be laid from the Post Office cable-laying ship "Alert" for the British Electricity Authority. For the contract a 132kV gas-filled cable, designed by W. T. Glover and Co., Ltd., has been chosen and the associated accessories have been designed by the British Insulated Callender's Cables, Ltd.

MODERN WHEEL DRIVE, Ltd., states that the company has received an order to supply two oil-operated reverse reduction gears, Mk. 3M.W.R., size 6, for the Yarmouth/Bar Harbour ferry, which is to be built by the Davie Shipbuilding Company, Lauzon, Levis, Quebec. The propelling machinery for the ship will have a total of 12,000 b.h.p., provided by two sets of three Fairbanks Morse engines, each developing 2000 b.h.p. at 750 r.p.m., and each set driving a propeller at 200 r.p.m. through a hydraulic coupling and a reduction gear. The company have also contracted to supply reduction gears for the Canadian Pacific Railway ferry to be built by Alexander Stephens and Sons, Ltd., which will be powered by two sets of two engines manufactured by the National Gas and Oil Engine Company, Ltd., each engine developing 1575 b.h.p. at 333 r.p.m., to give a total of 6300 b.h.p., and each set driving a propeller at 200 r.p.m. through a hydraulic coupling and an oil-operated reverse reduction gear, Mk. 2M.W.R., size 9.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ILLUMINATING ENGINEERING SOCIETY

Fri., July 10th.—NOTTINGHAM CENTRE : The University, University Park, Nottingham, "Midlands Area" Summer Meeting.

INDUSTRIAL WELFARE SOCIETY

Wed., July 22nd.—Robert Hyde House, 48, Bryanston Square, London, W.1, "The Role of Women in American Industry," Miss Frieda S. Miller, 3 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., July 15th.—LONDON GROUP : Visit by a party of members to the Vacuum Oil Company's Coryton Refinery, Essex, 1.45 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, July 3rd.—Summer Meeting, Newcastle upon Tyne.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, July 3rd.—Summer Meeting in Sheffield.

INSTITUTION OF MINING ENGINEERS

Wed. to Fri., July 15th to 17th.—Summer Meeting in Manchester.